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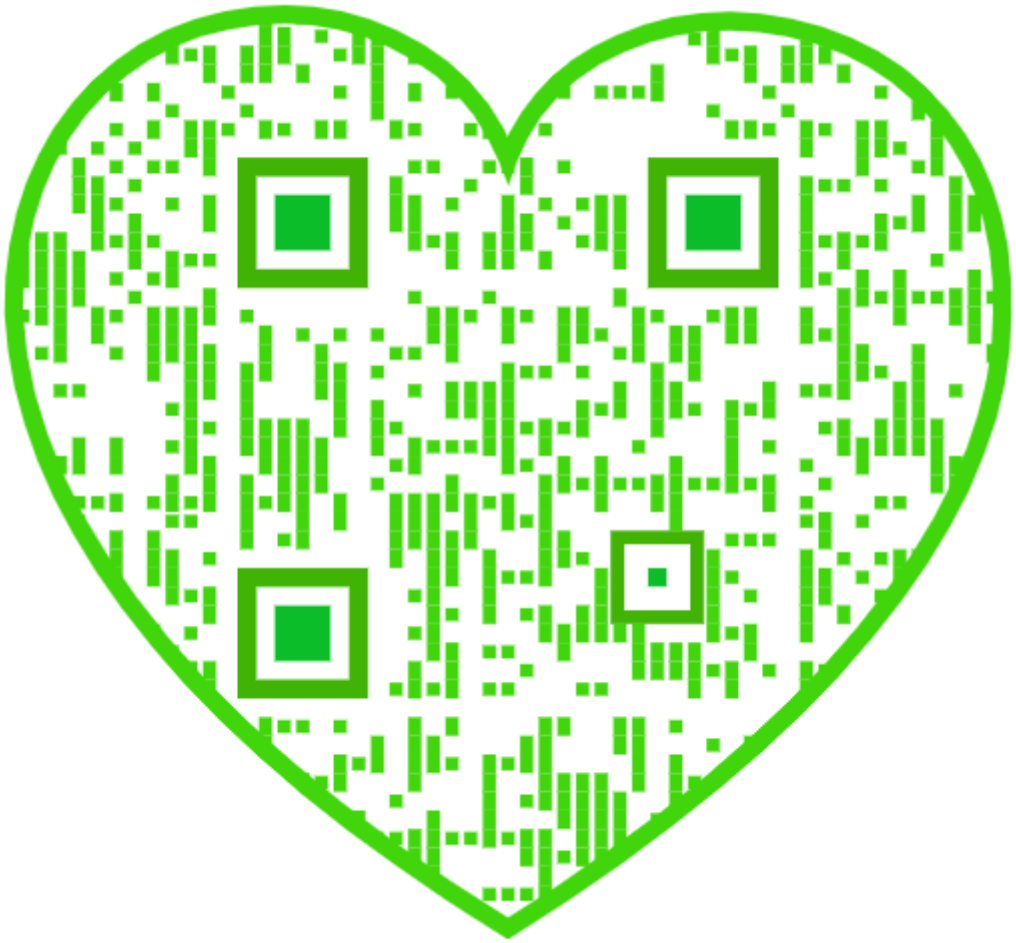

L. C.

ELECTRICITY IN COMMON WORDS.

ILLUSTRATED.

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ELECTRICITY

IN

COMMON WORDS.

A POPULAR DESCRIPTION OF THE PROGRESS, DEVELOPMENT AND APPLICATION OF ELECTRICITY.

BY

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AND

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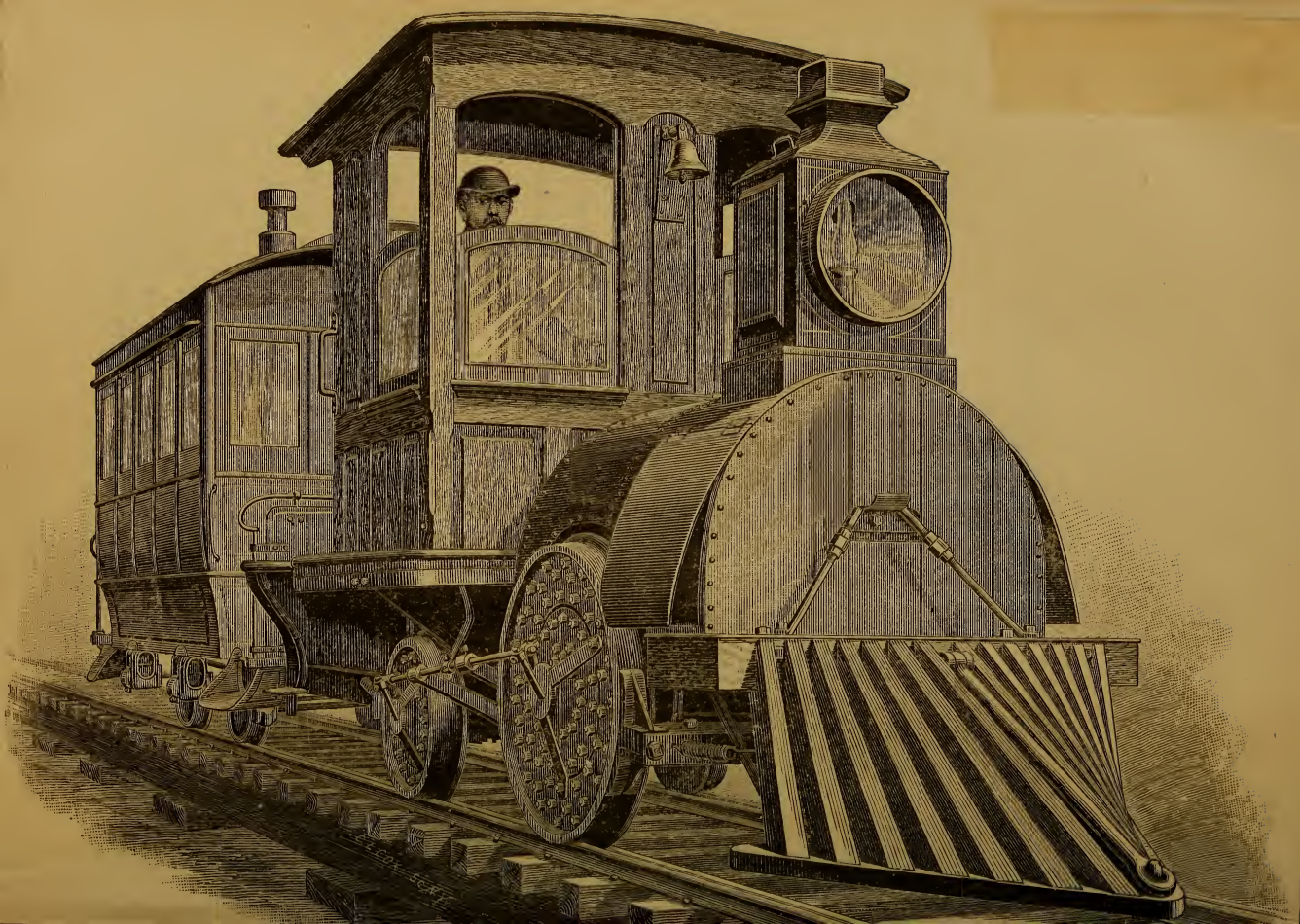
Table of Contents.

	Page.
Introduction,	5
What is Electricity?	11
Frictional Electricity,	18
The Grave of Franklin,	26
Galvanic Electricity,	30
Electro-typing,	35
Electro-plating and Gilding,	37
Electric Fuse,	39
Electric Bells,	41
Magnetism,	43
The Compass,	47
The Telegraph,	49
Electric Wires,	58
Telegraph Ocean Cables,	59
The Telephone,	64
Electric Light,	78
Dynamo-Electric Machines,	89
Gas Lighting,	96
The Electro-Motor,	104
Conclusion,	107



Introduction.

SURPRISING would it seem, in this evening part of the year 1884, if the pages of this brief volume were to put forth the statement, that in addition to the little ride you had just taken upon the Electric Railway between points not out of sight of each other, you were, before the next year closes, to speed across the continent by the same power. Furthermore, that ere you embarked, in addition to speaking with your friend in the far distant city you could recognize not only the voice, although but a whisper, but could see his face, and this alone through the medium of a feeble earth current or of one derived from the air itself by your little thread-like wire, which shall stretch its length along over the plains, up and down the mountains, through the forest, across the deep abyss, through the cable in the river's bed, and feeling a thousand differences of temperature on its way.

Would not the surprise be continued should it be stated that if on your journey you suffered delay, by

accident or otherwise, the danger would amount to nothing, for along the way automatic acting electric machinery would avoid collision, and prevent shock, even if your car should roll over the embankment; and that instead of disappointing your proposed guest as to the hour of arrival, you would only have to ask for the Telephone on the car, and, notwithstanding your speed of traveling and without regard to your location, you could have perfect facility for conversing with him and making a change of engagement; and that this would be accomplished without the necessity of metallic connection, for the strata of the air would be used.

Nor would the astonishment be abated if these opening pages should assert that successful experiment had been performed, by which transportation of persons and freight had been accomplished in one-tenth the time required by steam; that this statement is accompanied by the apology that only partial success had been attained, due to the fact that at this rate of speed it would be necessary, in long journeys, to take too frequent periodical stops to give passengers opportunities to breathe; while with the thorough mastery of these electrical appliances it is hoped in the near future to make all journeys, except the semi-continental ones, in the time

absolutely necessary for humanity to "take a breath;" that the journey would be accomplished before the interested traveler could read in the morning paper the new promise by Keeley, to his stockholders, of the day upon which the public (?) exhibition would be given on "Vaporic Force."

If such should be the prophetic opening of this volume, who would dispute the possible realization of these things; for if one stood in the gallery at the end of the great arch of the Electrical Exhibition, at Philadelphia, recently in such eminently successful operation, and reflected for a moment upon what was before him, what opinion would he venture as to what may not be accomplished within the next ten years?

With the exception of the large plate machines and Rhumkorff induction coils in the interesting exhibit at his feet, where else could he rest his eyes upon anything, which, in its commercially finished condition, dates back prior to our great Centennial year, which now seems but yesterday.

Would it draw painfully upon the imagination to read of *any* accomplishment in the use of this wonderful force within the next decade of years, starting as it does upon an

electrical basis compared with which the entrance of the past decade is as almost nothing?

Only a few details yet remain to be worked out before our railway trains will be lit by electric light, and, closely following this, heating and many other comforts will no doubt be added; for in this age of travelers, so much of life is spent on the cars that they almost become our moving homes, and home comforts are demanded.

Instead of making the work one of speculation or prophecy, the aim is to give a "popular" rendering of the subject, freeing it from the burden of the usual technicalities of the science, avoiding as far as possible all scientific expression, and adapting the reading to the wants of those who have neither the previous preparation, nor the time to read a volume in which the subject is treated from a scientific standpoint.

The object of the writers is to simply give a conversational knowledge of electricity.

The history, development, and most important applications of it will be traced down to the present. Of course it will be quite impossible in the scope of a hand-book to go into the details of the science, and explain, or even mention all its uses; but the cardinal principles and their application will be

considered, as deeply, no doubt, as the casual reader desires.

The watchword of the nineteenth century is "progress." Hence the field of science has been more carefully cultivated, and is producing more abundant fruits and practical results to-day, than in all the preceding centuries of the world's history. Indeed, there seems to be no avenue which scientists have not explored by observation and experiment, the result of which has been the grandest development of science, as applied to the comfort, convenience, and prosperity of mankind, that the world has ever seen.

Scientific principles no longer exist in the mind as fancies and day dreams, as of old; but by the intensely practical mind of to-day, they are utilized and made the hand-maids of prosperity.

No one department of science has attracted in recent years, or is attracting more attention just now, than that of electricity.

The expression in regard to the present adaptation of electricity, "It is but in its infancy" has become hackneyed, and falls flat in the ears of the toilers in this interesting and fascinating field of science, and yet none know so well how immeasurable seem the depths unexplored, as the worker

whose life is made up of one continuous thought as to its laws and its possibilities, and doubtless the wisest one of all who is tugging away at the curtains which veil the future from him, would not stop in his efforts to draw them back, and write its history with any anticipation of having the book complete and abreast of the present development, as its last pages leave his hands for the printer.

WHAT IS ELECTRICITY?

LITTLE did Thales of Miletus, Greece, six hundred years before the Christian Era, when he rubbed a piece of amber and observed it attracted light bodies, think that he had discovered the force, the development of which would lie and wait so long for the unfolding of its valuable secrets, or that within the space of a few decades it would take so great a part in the science and commerce of the world.

His conclusions at that time were that an unknown spirit or element animated the amber, that when rubbed, this spirit was aroused, and, leaving the amber, went out after these light particles, and returning with them caused them to adhere to the surface. The Greek word *Electron* means amber, and from it we have derived our word electricity.

Theophrastus, a Greek, discovered, some centuries later, that the same attractive property resided in a crystal, now thought to be the tourmaline. Pliny says that the scientists of his time were well acquainted with the attractive power of amber; and, indeed,

certain other bodies were known to the ancients to manifest the same property, upon being rubbed.

It will thus be seen that the science of electricity is old in its inception, but, as the reader will hereafter discover, it has been remarkably slow in its development, and its practical application to the wants of mankind has only become an accomplished fact during and since the second quarter of the present century.

Pliny says nothing to warrant the conclusion that the scientific men of his time had added anything to the knowledge of electrical phenomena, possessed by the philosophers of the preceding six centuries; and it was not until towards the close of the sixteenth century, that the first attempt was made toward a classification, or generalization, of electrical phenomena, or manifestations. This attempt was made by Dr. William Gilbert, in a treatise on the magnet.

A century later, Dr. Wall, Boyle, Newton, and others, ascertained many additional facts, but they were not of such a character as to furnish data from which the principles of the science, as now understood, could be evolved.

Not until 1728, was it discovered that electricity would pass quite readily through certain bodies. Mr. Stephen Grey, who made this discovery, classified bodies into conductors and non-conductors. This classification is not now accepted as being abso-

lutely correct, since all bodies possess the property of transmitting electrical force in a greater or less degree. However, for all practical purposes the classification is correct, and bodies are called conductors and non-conductors.

Those bodies, which offer but little resistance, such as silver and copper, are called good conductors; and those which offer great resistance, as gutta-percha and glass, are termed poor conductors, or insulators. Hence, for convenience of expression, we speak of a current of electricity and electric fluids, though in reality there is no such thing. The expression must be understood as figurative only, as will be presently shown.

To Du Fay, a French philosopher, belongs the honor of discovering two opposite states of electrical excitation; or, in other words, positive and negative electricity. Why there are two kinds of electrical force, and why when two bodies are rubbed together one will be found to possess positive and the other negative electricity; or why the same body exhibits different kinds when rubbed by different substances, we do not know.

For example, polished glass is electrified positively when excited with flannel, but negatively when rubbed with cat's fur; again, rough glass rubbed with flannel is negatively electrified, or excited, but positively electrified when rubbed with oiled silk.

The two kinds are always produced at the same time, and never

exist separately and independently of each other. In other words it is impossible to have one without the other. Again all bodies cannot be electrified, or excited, with equal facility. When they are easily excited, they are called electrics, and are poor conductors; when they are hard to excite, they are termed non-electrics, and are good conductors. Metals generally are non-electrics.

It is only by actual experiment that we can ascertain when a body will produce positive, and when negative, electricity. There is no law by which it can be previously determined; but the same kind of electricity will always be produced in the same body under the same conditions.

The peculiar power, called electricity, is known to us only by its effects. Many theories, respecting its nature, have been advanced, but only three can be briefly noticed, viz: that of Du Fay and Symmer, that of Franklin, and the dynamic theory as taught by Tyndall, Grove, and others.

Du Fay and Symmer supposed electricity to be an infinitely thin fluid, pervading all bodies, and composed of two elements, each having distinct and opposite properties. These elements they called vitreous and resinous electricities. Each was supposed to balance or hold the other in check, when combined, repose being the result. When, however, a separation between

these elements took place, each became active. This theory attributes electrical excitation to a separation and taking away of one of the elements, leaving the other in excess, or unbalanced.

The theory of Franklin supposes the existence of a single fluid of extreme thinness and elasticity, and distributed equally throughout all substances. This fluid is thought to repel its own particles, but to attract all other matter. If distributed in bodies in quantities equal to their capacity or attraction for it, such bodies are said to be in their natural condition. When the natural quantity of electricity in a substance is increased or diminished, excitation takes place, and the substance is said to be electrified positively when possessing more than its natural quantity, and negatively when possessing less.

The dynamic theory assumes that, from its creation, the earth has always possessed, and still possesses, a given amount of force or energy: That like the quantity of matter, it has never been increased or diminished: That heat, light, and electricity are all but different manifestations of the same force, and each is convertible into the other: That heat is produced by setting the molecules, or small particles of matter, in rapid vibration, which vibrations, striking the body, produce the sensation we call warmth (all have noticed the vibrations or waves of air proceeding from a hot stove or a tin roof on a hot summer's day): That light is but

the effect produced by the vibrations of ether, which strike the eye: That electricity, like heat and light, which were once thought to be exceedingly subtle forms of matter, is but a mode of force, which sets the molecules of ordinary matter in vibration and polarizes, or turns them in a certain direction. This theory has superseded the fluid theory and is now accepted by the scientific world as being correct. We know that electricity will produce both heat and light, and that heat in turn will produce electricity. Since the advancement of this theory the development of the science has been very rapid.

In passing, it is but just to say that though the theory of Franklin has been exploded, yet he was the first to reduce electricity to order, and his experiments and memoirs on electricity and other physical subjects gained him admission to the highest scientific societies in Europe, and have given him a permanent place in scientific history.

A short and intelligent account of the nature of this wonderful force having been given two general rules or principles will now be stated, which the reader must remember in order that he may understand the processes and appliances hereafter described.

The first principle is *that bodies possessing like electricities will repel each other; but those possessing opposite electricities will attract each other.*

In other words two bodies charged with positive electricity, or two bodies charged with negative electricity, will repel each other; but when one is charged with negative and the other with positive electricity they will attract each other.

This may be illustrated by rubbing a glass tube with silk and holding it near two pith balls suspended by silk cords. They will immediately fly to it and become charged with the same kind of electricity; upon withdrawing the tube, instead of hanging near each other, as before, they will fly apart and remain in that position until they gradually lose their electricity.

The second principle is *that a current is produced when there is a suitable medium or conductor between the positive and negative electricity, because of their strong affinity for each other.*

The subject will be further treated under the heads of Frictional Electricity, Voltaic Electricity, and Magnetism.

Frictional Electricity.

One of the commonest sources of electrical excitement is friction. As the reader has doubtless observed, frictional electricity first attracted attention. In horse's hair and cat's fur it is usually very abundant, and is frequently seen in frosty weather while grooming horses in a dark stable, or stroking violently the fur of a cat.

It is, also, sometimes manifested by the cracking sound produced by passing a gutta-percha comb through the hair when it is free from dampness; also by the rising of the hair. It is often produced in great abundance in factories by the friction of the bands on the wheels, and sometimes a spark two or three feet in length may be seen.

When we rub two bodies together, the rubber and the rubbed body always assume opposite states, both positive and negative electricity, the reader will remember, being produced at the same time.

In performing experiments in frictional electricity, glass is generally used to produce it, as it is very cheap, easily obtained,

and serves the purpose quite as well as other substances.

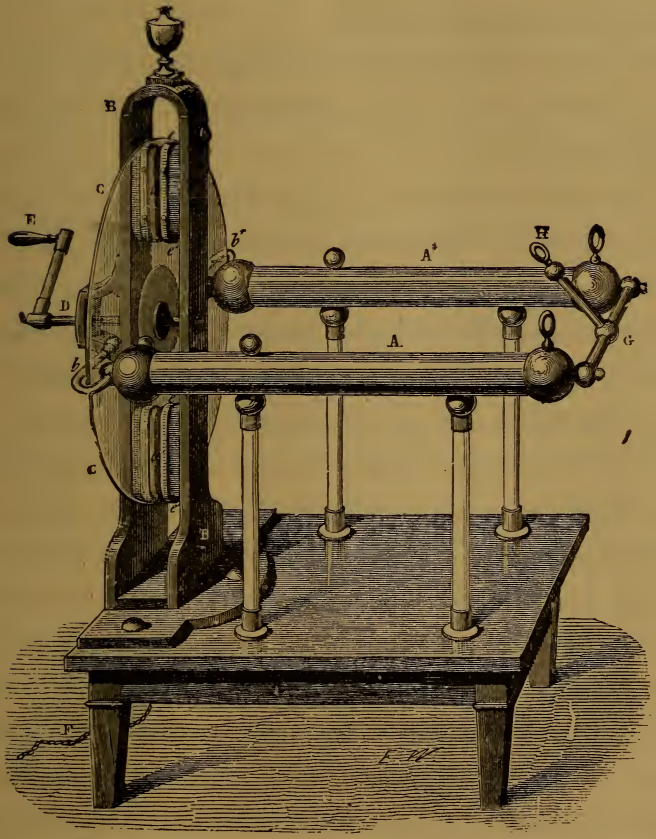


PLATE MACHINE.

For this purpose the plate machine is used and may be de-

scribed as follows: A circular plate of glass is fixed upon an axis, and made to revolve between two leather pads covered with a mixture of tin, mercury, and zinc.

The pads, rubbing against the plate, produce the electricity, which is conducted from the machine in various ways for performing experiments.

If, while the machine is in operation, the knuckle be placed near the conductor (which becomes charged with electricity from the revolving plate, and the view here presented gives a good idea of the plate machine), a spark attended by a sharp crackling sound will dart to the hand, producing a stinging sensation.

Dr. Wall was the first to notice the electric spark. It is caused by the electricity passing through the air, and is produced when the conductor and the electrified body are not too far apart.

If a person stand on a stool having glass legs, which prevent the electricity from leaving the body, and take hold of a chain fastened to the conductor of the machine, sparks may be drawn from any exposed part of the body, by a second person bringing his finger near the one on the stool, when the machine is in operation. Du Fay and the Abbé Nollet were the first to discover this. It attracted great attention and became a kind of fashionable diversion at the time.

The idea of accumulating and retaining this force suggested

itself, and in 1745 and 1746 many attempts were made to confine it in glass vessels containing water or mercury. It was then discovered for the first time that shocks could be received. But it was not until the invention of the Leyden jar (so called from its having been invented in Leyden, Holland), that electricity could be bottled up, so to speak, and kept for an indefinite length of time.

The jar is made by covering an ordinary glass jar inside and outside with tin-foil to within a few inches of the top. A dry varnished cork is placed over the mouth of the jar, and through the cork is run a wire, which ends above the cork in a brass knob, and below it in a chain, which rests on the bottom of the jar, thus coming in contact with the tin-foil. If a glass tube be rubbed with flannel or silk and repeatedly held near the knob of the jar, or the knob be held near the conductor of a plate machine, when it is working, the electricity will pass off in a succession of sparks and be collected on the inside and outside of the jar.

The inside will be charged with positive, and the outside with negative, electricity, which the non-conducting glass between them prevents from uniting. But if one hand be put on the tin-foil on the outside of the jar, and the other on the knob, the circuit will be completed and a shock will be felt in the arms when the jar is small and in the chest when it is large. A number of these jars, having their knobs all united, may be made to form a battery, and

may be charged with electricity or discharged in the same manner as a single jar.

By means of this jar a shock has been given to as many as 12,000 persons at the same time by their joining hands and the persons at the ends of the line touching, one the knob and the other the outside of the jar.

The analogy between lightning and electricity seems first to have been noticed by the Abbé Nollet, but Benjamin Franklin was the first to prove that the electric spark and lightning are the same; and that thunder and lightning are caused by a discharge between two clouds charged with opposite electricities.

In 1752, Franklin resolved to test the truth of his convictions by trying to gather electricity from the clouds during a thunder storm. He accordingly made arrangements for extending a wire to a great height from a steeple in course of erection in the city of Philadelphia. While waiting for the completion of the steeple, he one day noticed a boy's kite higher up in the air than he could possibly extend the wire, and the thought flashed upon him that he could perform the experiment by using the string as a conducting wire. The kite was covered with a silk handkerchief to prevent its being destroyed by the rain and wind. A sharp pointed wire was placed above it to collect the electricity. The loose fibres of the twine string were soon seen to stand out in all directions, and,

putting his knuckle to the key fastened to the string, he drew off a spark. When the conducting power of the string was increased by its becoming wet, a Leyden jar was charged with which several experiments were performed. Thus it was established beyond a doubt that frictional electricity and atmospheric electricity are the same. This was regarded by scientists at the time as the greatest discovery of the age, and of itself was sufficient to immortalize the name of Franklin.

Electricity is always present in the atmosphere in a greater or less degree, usually most abundant three or four hours after sunrise and sunset, and increases in quantity with the distance from the surface of the earth. Very little is known as to the cause of atmospheric electricity. Various causes have been assigned, among which may be mentioned the following:

1. The friction produced by large bodies of rarefied air rubbing or chafing against denser or heavier bodies of air.

2. To the condensation of vapors in the air, especially during a rain storm.

3. To the chemical changes produced in the atmosphere by the growth of trees and plants.

4. To the evaporation of the water of stagnant ponds and marshes, which contain a great quantity of decaying vegetable matter.

As the conditions are not the same at all seasons of the year and in all places, so the amount of electricity in the atmosphere is greater in some places and during some seasons than at others. It is a noticeable fact that the loss of life and property caused by lightning is greater in rural districts and country towns and villages than in large cities.

Atmospheric electricity has its grandest manifestations in the vivid flashes and bolts of lightning which dart across the heavens and thrill us with their awful grandeur.

The most destructive form of lightning is the forked, which takes a zigzag course because it travels so rapidly as to condense the atmosphere ahead of it; and when it can find an easier path by darting to one side, it immediately does so, always taking the easier path.

Sometimes atmospheric electricity exhibits itself in brilliant balls of fire at the yard arms and mast heads of vessels; sometimes, in a brilliant light on the tops of masts and at the points of bayonets. Such manifestations are known as St. Elmo's Fire, and occur only when the air is surcharged with electricity. The Aurora Borealis, or Northern Lights, is also attributed to the electrical condition of the atmosphere.

The velocity with which lightning travels is not known, but various experiments show that electricity travels from 11,000 to

288,000 miles per second, the rate depending upon the kind of conductor used and the intensity of the current. In other words, when a copper wire is used, it can be made to girdle the earth nearly twelve times in a second—a fact which is almost beyond the power of the imagination to conceive. Frictional electricity being more intense than voltaic of course travels faster.

Conductors which are pointed have been found to be the best, and hence lightning-rods are always pointed and the points are covered with silver or platinum to keep them from rusting and thus losing a part of their conducting power. If the conductor is good and of sufficient size, the electrical discharge takes place silently; but if it is poor, the current, which cannot be hindered, will, if sufficient, destroy or demolish the conductor, as when lightning strikes a house or a tree.

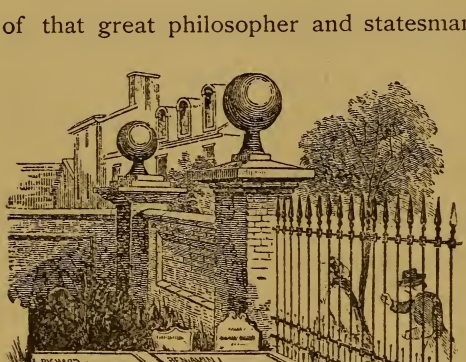
It is quite probable that a great deal of electricity is silently conducted by lightning-rods from the atmosphere to the earth. Death to persons and animals is due to the fact that their bodies offer sufficient resistance to the passage of the current to fatally paralyze the nervous system.

Frictional electricity has no practical value as the largest plate machine is but one-tenth horse power. Its chief use is to illustrate the science in colleges and schools, and particularly atmospheric electricity.

The following description, taken from *The Electrical World*, of the grave of the illustrious Franklin may be of interest to the reader:

THE GRAVE OF FRANKLIN.

About half a mile westward from the Delaware river, at Fifth and Arch streets, in the busiest part of Philadelphia, lie the mortal remains of that great philosopher and statesman, Benjamin Franklin. Like many others of those intramural cemeteries so frequently met with in Philadelphia, Christ's Church graveyard is now hemmed in on every side by factories and stores. It is surrounded by a high brick wall, fast decaying from the storms of nearly two centuries; and were it not that a breach, probably ten feet wide, was torn out in 1858 and an iron railing substituted near Franklin's grave, the casual passer-by would not know that he was in the neighborhood of a cemetery.



Upon entering the yard the visitor finds himself in groves of elm and chestnut trees, with tombs on every side of him. There is little sign of care-taking. Some of the tombstones are broken; from others, still standing, the inscriptions have been worn away by the elements,

while others have fallen and lie covered with moss and hidden in the underbrush. But the visitor has left behind him the noise and bustle of the street, and he is soon beside the grave of the immortal "Poor Richard."

This interesting spot is at the corner of the yard, as shown in the engraving, where Fifth intersects Arch street. The grave is covered by a slab lying on the turf, and bearing the simple inscription:

Benjamin and Deborah, } Franklin, 1790.

A stately elm tree, not shown in the engraving, springs directly from the foot of the tombstone, so closely that its roots must by this time have extended through the grave, and spreads its branches over the neighboring street. A broken flower-pot with a faded flower rests on the slab, and all else is left to the imagination of the pilgrim.

At the head of the grave are two small upright stones, one to the memory of John Read, the father of Mrs. Franklin, and the other to "Francis F., son of Benjamin and Deborah Franklin, deceased Nov. 21, 1786, aged 4 years, 1 month and 4 days." Next to the Franklin grave, to the southward, is a similar stone, inscribed simply:

Richard and Sarah } Bache, 1811.

the daughter and son-in-law of Franklin. Some years ago, in excavating a part of the yard, a tombstone was discovered which bore the name of Dennis Franklin, a child of the great philosopher, who died at an early age.

It first occurs to the pilgrim that this perfect model of a hard-headed,

intensely practical American should have a monument more expressive of his grand political, literary and scientific record; but a little reflection shows that the plain stone and that quiet nook under the elm reflect the character of Franklin better than could a glowing epitaph. It was his wish, expressed in his will, to be buried "with as little expense or ceremony as may be," by the side of his wife, who was buried here Dec. 22, 1774; that "a marble stone, to be made by Chambers, six feet long, four feet wide, with only a small moulding round the upper edge, and this inscription:

Benjamin and Deborah } Franklin, 178–,

be placed over us both."

It will thus be seen that he fully expected to die in the decade between 1780 and 1790, yet he survived the companion of his joys and troubles sixteen years, and did not join her in their silent resting-place until April 18, 1790.

It may be worth while also to refer, as a contrast, to the epitaph which Franklin wrote for himself in 1728, when he was but 23 years of age:

The Body
of
BENJAMIN FRANKLIN,
Printer,
(Like the cover of an old book,
Its contents torn out
And stript of its lettering and gilding,)
Lies here, food for worms.
But the work shall not be lost,

For it will (as he believed) appear once more
In a new and more elegant edition,
Revised and corrected
by
THE AUTHOR.

But his later life has taught us that imperishable fame does not rest upon the successful manœuvres of a victorious army, and that Peace hath her victories no less than War. Muffled bells were tolled and minute guns boomed, while twenty thousand people followed this plain man to this grave. The nation's—the world's—sorrow was best exemplified by the great Mirabeau, who, in announcing the death of Franklin to the French Assembly, spoke of him as "the Sage whom two worlds claim; the man whom the history of Empires and the history of Science alike contend for. * * * * *

Galvanic Electricity.

Galvanic electricity takes it name from Galvani, a professor of anatomy in the University of Bologna, Italy.

About the year 1789, he accidentally discovered that bringing the legs of a frog, which he had recently killed, in contact with copper and iron produced convulsive motions in the limbs. He supposed this peculiar force to depend upon the nerves and muscles for its action; but Volta, of Pavia, in the year 1800, went a step further and showed that the action was due to bringing the two metals into chemical contact.

On this theory he constructed his celebrated "pile," which consisted of a number of plates of copper and zinc, having cloths saturated with a weak acid placed between them, first a plate of copper, then one of zinc, and so on until the pile was completed. The whole was placed on glass (it being a non-conductor) and a wire attached to each end. The wire fastened to the zinc plate at the top of the pile was found to yield positive, and the one united to the copper plate at the base negative, electricity. A bright spark was produced by bringing together or separating the ends

of these wires. Shocks could also be received, slighter than those from the Leyden jar, their force depending upon the number of plates. When a short piece of platinum was attached to the ends of these two wires, thus uniting them, it was heated red hot (the platinum being a poor conductor).

The pile may be shown on a small scale by putting a piece of zinc under, and a piece of silver on, the tongue, and allowing the two to come in contact. As soon as they touch, the circuit is formed (the chemical action being caused by the saliva), and a peculiar sensation is felt in the tongue, accompanied by an unpleasant taste. If the eyes are closed, a faint flash is seen.

Volta's was a very important as well as useful discovery, and has led to the construction of numerous batteries, all based upon the principle of chemical action as a generator of electrical force, and differing only in the amount of force produced and the cost of production.

A brief description of one of these batteries will illustrate the principle upon which they all operate. For illustration, Smee's, being a simple battery, will now be described.

Three metallic plates are suspended from a wooden frame and kept separate from each other. The middle plate is of silver and coated with platinum. The two outside ones are zinc coated with mercury. The whole are placed in a glass or earthen jar,

containing dilute sulphuric acid. As soon as communication is established between the metals, a bubbling commences in the liquid, and voltaic electricity is produced.

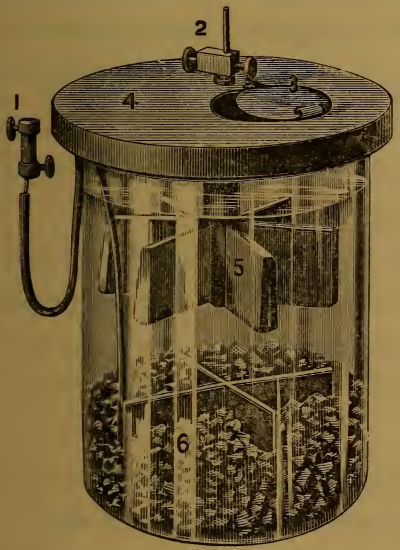
It may be interesting to the reader to know the theory of the action of the galvanic, or voltaic, battery. The most generally accepted theory may be briefly stated thus:

Water is composed of two elements, oxygen and hydrogen; and when connection is formed between the copper and zinc plates by means of water containing acid, the water is separated into these two elements. The zinc having a strong affinity for oxygen, attracts it and forms oxide of zinc. The hydrogen, being set free, collects and forms small bubbles around the copper plate. This action causes the zinc to lose its positive, and retain its negative, electricity. The copper attracts the positive electricity, and thus a current may be formed between the zinc and copper plates, opposite electricities always attracting each other. To produce a current, it is only necessary to fasten one wire to the copper plate and another to the zinc plate and close the circuit by allowing the ends of the wires to touch each other. These ends are called the "poles" of the battery—positive and negative.

The use of the acid in the water is to dissolve the oxide of zinc, which forms on the zinc plate, and so keep a fresh surface of the metal constantly exposed. This is why a galvanic battery is

constant in its action, so long as it is kept supplied with plates and acidulated water.

Chemical action is supposed to be always accompanied by the development of electricity, though in its effects it may be so slight as to be imperceptible.



CALLAUD BATTERY.

The Callaud is the most complete form of Voltaic battery, which has been adopted for general telegraphic purposes in the United States, and is called after the name of the designer of this type.

For a clear description of its parts access may be had through the system here presented of numbering its parts.

NAMES OF PARTS.

1 Battery Copper Connector.
2 Battery Zinc Connector.
3 Syringe hole cover.
4 Wooden cover.
5 Battery Zinc.
6 Battery Metallic Copper pole and Sulphate of Copper. Jar 6 x 8 inches.

This form of battery requires very little care.

Galvanic electricity differs from frictional electricity in being greater in quantity, but weaker in intensity. Frictional electricity is convulsive, sudden, and noisy; galvanic is powerful, constant, and silent. The lightning will dart through miles of intervening atmosphere, but a break in the circuit suspends all electrical action of the battery. It would encircle the earth rather than bridge a disconnection though but the fraction of an inch. An ordinary galvanic battery will produce the same chemical effects that could be produced by a flash of lightning.

This last fact has led to the processes of electrotyping and electro-plating, which will be hereafter described. The differences pointed out will explain why galvanic electricity can be successfully employed in connection with the telegraph and the telephone, and frictional cannot.

Furthermore, galvanic electricity may be constantly generated by the battery and always ready for use, without the aid of any machinery, which is necessary to develop frictional electricity in quantities sufficient for practical purposes. It is therefore cheaper.

Because of its peculiar action on the nerves and the muscles, galvanic electricity is often applied to stimulate and restore them to activity in cases of paralysis and in acute forms of rheumatism. It has thus become a very valuable adjunct to the science of

medicine. It is also applied to the body in the form of an electric hairbrush, and by means of electric dumb-bells.

Under this division of the subject will be described Electro-typing, Electro-plating, the Electric Fuse, and Electric Bells, as they more properly belong to it than to any other branch of electricity.

Electro-typing.

The chemical effects and decomposing power of the galvanic battery are finely illustrated in the processes of electro-typing and electro-plating.

Electro-typing was invented in 1837, by Professor Jacobi, of St. Petersburg, and is done in various ways, one of which is the following:

Wax is spread over a page of the type and an exact impression is made upon the wax by strong pressure. Then the wax

mold is removed and the face of it is given a metallic surface by covering it with pulverized plumbago (lead used for pencils). This is done to make the metal, deposited upon it, adhere to it.

A solution of sulphate of copper, which is composed of sulphuric acid and copper, is put in a trough or vessel. Both the mold and the copper plate are submerged in this solution, the mold being placed at the negative, and the copper plate at the positive, pole of the battery.

As soon as the battery commences to operate, the sulphuric acid and copper in solution are separated, the copper being drawn to the negative pole and deposited upon the mold, while the sulphuric acid goes to the copper plate, and combining with it furnishes a fresh supply of the solution.

In this way the action goes on until a film of sufficient thickness is deposited upon the mold. When the film or shell has become as thick as a sheet of heavy writing paper, the mold is taken out of the solution and the shell is taken off.

It is then coated with tin, because type metal, with which it is backed up, will not adhere well to copper.

The shell is next placed on a plate, face downward, and suspended over a bath of melted type-metal. When it has become as hot as necessary, the molten metal is dipped up and poured over the back of the shell. The plate is then allowed to cool and

is made of a uniform thickness by means of a planing machine. When used for printing it is placed in a wooden frame.

Plates can be made of type-metal, but copper is preferred, if the book is likely to have a large circulation, as it is harder and more durable.

The invention of this process has very greatly reduced the cost of books, as the type need be set up but once; and after the plates are made, it may be broken up and distributed for use again. Furthermore, other editions of the book can be gotten out sooner than the first, because the delay of setting up the type is avoided.

Electro-plating and Gilding.

This process dates back to an earlier period than electro-typing.

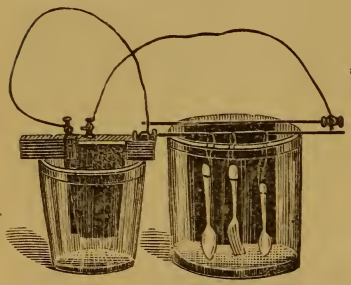
It was shown by Mr. Wollaston, in 1801, that a silver coin could be covered with copper by means of the galvanic battery. The coin was burnished to prove that the plating was durable.

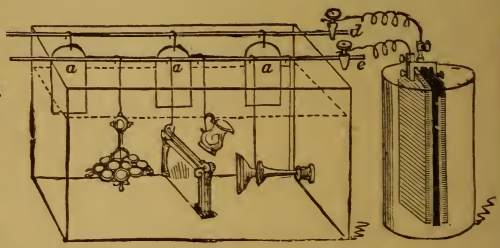
It was not, however, until 1838, that this process was turned to practical account. Since then it has grown in importance, and

is now used in plating table ware, jewelry, gilding lamp-posts, monuments and various other things.

Silver-plating is done in the following manner:

A chemical solution of silver is placed in a glass or trough. Into this solution are placed a piece of silver and the article to be plated, the silver being attached to the positive pole and the article to the negative pole of the battery, as may be seen by the following cuts:





When the battery is put in operation, the silver in solution is carried by the current to the negative pole and deposited upon the article, giving it a dead or frosted appearance.

If, however, it is desired to polish the article, a few drops of bi-sulphide of carbon are put in the bath and have the effect of giving the plating a lustre.

It is necessary to have the articles perfectly clean to give them a durable coating. This is accomplished by first putting them in

a boiling solution of potash to remove all grease from them. They are next dipped into a weak solution of nitric acid to remove any canker that may be on them, after which they are washed thoroughly.

A single, double, or triple plate is formed according to the length of time the operation goes on. From three to six hours is the usual time required to give a good plating.

One-half ounce of silver to the square foot makes an excellent plate.

After the desired plate is given to the article, it is brushed well with a fine brass wire brush, which is revolved by a lathe. Finally, it is cleaned with fine Calais sand and polished.

Gilding is done in much the same way, the principle being the same.

Electric Fuse.

An important application of electricity is exhibited in the electric fuse, which is used to explode the charges of powder or other material used in blasting, and torpedoes submerged under the water for the purpose of blowing up ships.

By means of this fuse blasting has been made safe, as the charge may be ignited and the rock blasted when the workmen have gone a mile or so away.

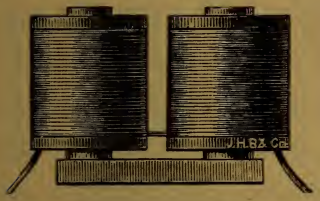
Some will doubtless remember that the famous explosion of Hell Gate, on the East river, was accomplished by a little girl's touching a porcelain knob and thus completing the circuit, and so causing the current to flow to the igniting point, and instantly the rocks, which had for all time past made the entrance from the ocean via Long Island Sound into the port of New York a perilous passage, were riven asunder and made easily removable.

The electric fuse is constructed in different ways, the principle in all cases being the same, viz: that of passing a current of electricity through a chemical mixture or a fine platinum wire, which, being a poor conductor, is heated and ignites the fulminate or charge through which it passes.

The more resistance a body offers the hotter it becomes, so that even platinum, which is very hard to melt, has been fused. This principle will be more fully explained in the description of the electric light.

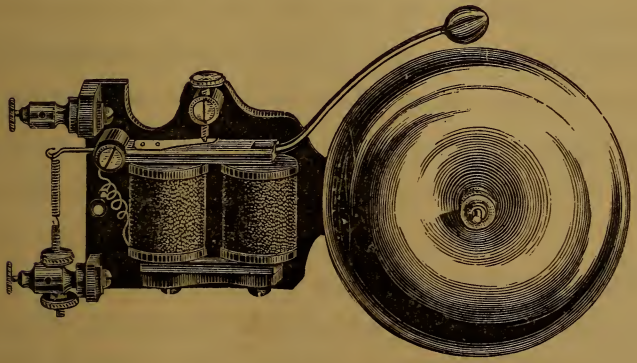
Torpedoes are so arranged that the operator may complete the circuit and explode them at will, or the circuit may be completed by the vessel's coming in contact with a submerged wire.

Electric Bells.



WOUND SPOOLS.

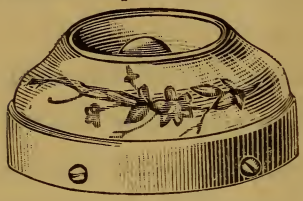
Electric bells are used for many purposes where quick and audible signals are required for calling attention, and are constructed of an electro-magnet, or pair of wound spools, and a clapper, which being hung near the ends of the spools is acted upon by the electric current and drawn to strike the gong, which with the other parts is fastened to a base.



ELECTRIC BELL.

In a vibrating bell a spring is fastened to the armature or clapper parts in such a way as to cause the interruption of the

circuit every time the clapper moves and strikes the gong and is so returned, the result being a trembling ring as long as the push button is pressed.



PUSH BUTTON.

Any combination of signals may be arranged, and the same bell answer to call the "man-servant, maid-servant" or "stranger that is within thy gates," or to call you when the "stranger" has entered your dwelling uninvited and for robbery or possibly worse purposes.

In burglar alarms small contact points are caused to be touched by raising the windows, opening the doors, or stepping upon rugs designed for the purpose, or by cutting into your silver chest which in its every part—panel and post—contains a double thickness of metal, insulated from each other and making up the electric circuit, and must, by its design, be caused to touch in case of being punctured and so cause the alarm bell to be rung.

The best form of burglar alarm equipment includes an annunciator which is made up of a set of magnets, one for each room or department of your house, or premises, and so connected by wires carefully concealed; the action being, that if a door or window is opened a current of electricity is made to flow through the mag-

net for that room, a little leaf falls down showing the name of the room and the bell rings, and without delay the warning is given and advantages over the intruder presented.

In railway signaling and telephoning, bells are rung over circuits of many miles in length.

Magnetism.

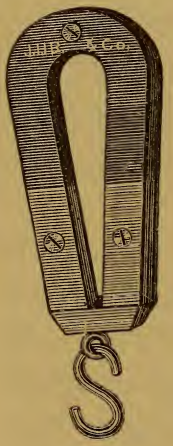
The discovery of the magnet dates back to the time of Thales, a Greek, who discoursed upon it 640 B. C. Reference is also made to it in the writings of Homer, Aristotle, and Pliny. "The magnet-stone" says Pliny, "is found in Cantabria."

Five hundred years before the Christian era, it was supposed that gout in the hands and feet and convulsions could be cured by the patient's holding a loadstone in the hand. In the fifteenth century it was employed as a cure for toothache, and a little later its beneficial effects were secured in the shape of magnetic tooth-picks.

Only natural magnets, or loadstones, were known to the ancients, and with these they magnetized needles, which they used in making compasses.

It was not discovered until the year 1820, that artificial magnets could be made by passing an electric current through a bar of iron or steel. Magnets made in this way are called electro-magnets. This was a very important discovery as will be hereafter shown.

The power of loadstones is almost incredible. Sir Isaac Newton wore one in his ring. It weighed only three grains but would lift 746 grains, or nearly 250 times its own weight. The cut shows a horse-shoe magnet holding weight at its extremities.



HORSE-SHOE MAGNET.

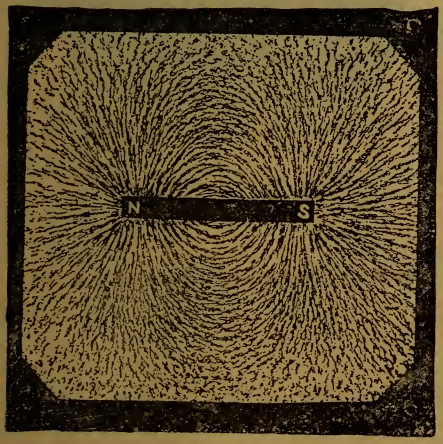
There are numerous kinds of artificial magnets, which take their names from their shape, as bar-magnets, horse-shoe-magnets, and magnetic needles.

Steel and cobalt are found to be best suited for making permanent magnets, because being hard they retain the magnetism. Soft iron and nickel may be used to make temporary ones, because these metals soon lose their magnetism.

The attractive force of the magnet is not distributed equally through it, but is found to be

greatest at the poles or ends. If, however, a magnet be broken into any number of pieces, each piece will become possessed of a negative and a positive pole. In the centre it has no attractive power whatever.

A thin intervening substance does not interfere with the attractive power of the magnet. This may be shown by scattering steel filings on a sheet of paper, and placing it above the magnet. The filings will collect around the poles in groups, as will be understood from the following two cuts.

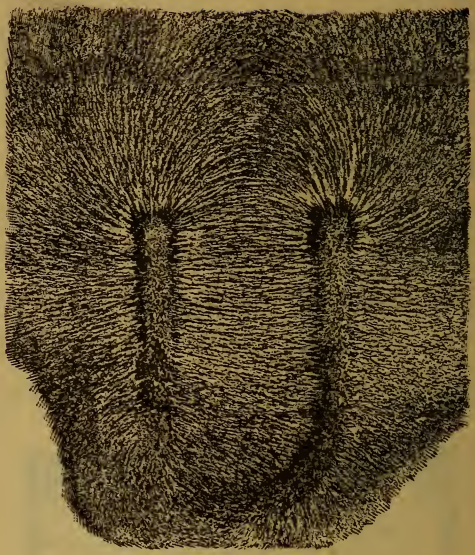


MAGNET WITH FILINGS.

The general law of magnets is the same as that of electrical attraction and repulsion, viz: that like poles repel each other and unlike attract.

The theory of magnetism is the same as that of electricity previously stated, viz: a mode of force which polarizes, or turns, all the molecules in a certain direction. Hence the magnet is but another form of electrical force.

All the extensive practical and useful applications of electricity have been made by means of the magnet. Under this division of the subject, the Compass, the Telegraph, the Telegraph Cable, the Telephone, the Electric Light, and the Electro-motor will be described, as they all embrace the magnet in some form.



MAGNET WITH FILINGS.

The Compass.

If the magnetic needle be suspended or poised so as to move freely, it will always point north and south, or nearly so. The same end invariably points north, leaving the other end pointing south.

This can only be explained by considering the earth a great magnet, having its south magnetic force concentrated in the Northern Hemisphere. Hence the north pole of the needle points in that direction, and the south pole of the needle points towards the north pole of the earth, which is the Southern Hemisphere, because opposite poles of the magnet attract, and like poles repel, each other.

Whether we call a certain end of the needle the north pole, or the south pole is only a matter of custom, as we could consider the north pole of the earth to be in the Northern Hemisphere, and the end of the needle which points in that direction the south pole of the needle.

The fact that the magnetic needle invariably points in the same direction seems to have been discovered at a very early date, and led to the invention of the mariner's compass, which is

supposed to have had its origin in China. It was successively introduced into India, Arabia, and Europe.

If the Chinese annals are to be credited, it was known to that people and used by them nearly 3000 years ago; but it probably consisted of nothing more than a piece of loadstone fixed on a cork and placed on smooth water.

The mariner's compass now used may be described as follows:

A needle is magnetized and placed upon the point of a short pivot or post. A round card, having the cardinal points and smaller divisions marked upon it, is attached to the needle in such a manner that both the card and the needle may freely float around according to its magnetic impulse. The number of points on the card is thirty-two, and they are subdivided into half and quarter points.

Reading these points is termed boxing the compass. The needle and card are enclosed in a brass case, as brass has no attraction for the needle and will not affect or influence its direction.

The box containing the compass is hung on gimbals in the binnacle, so that it will always be in a horizontal position, no matter how much the vessel may pitch and roll. Thus the face of the compass is always turned upward and the course of the ship may be easily ascertained.

The surveyor's compass and all kinds used on land have the needle placed above the card.

That a compass may be good, it is necessary that it should be steady, active, and easily influenced; and that it should be made so that it may be easily corrected, when it has deviated by local attraction.

The invention of this instrument has made it possible to traverse the oceans and seas with almost unerring certainty, and has converted them into great highways over which the commerce of the world is carried.

The Telegraph.

Various means have been employed to transmit messages between distant points, but only four of the different systems based on the action of the galvanic battery will be described, viz: Sömmering's, Morse's, Bain's, and House's systems.

An endeavor was made to use frictional electricity for the transmission of messages, but it was not until after the discovery and the various improvements of the galvanic battery, that a continuously working instrument could be produced.

The present system of telegraphy owes its existence to the fact that a current of electricity passed through a bar of iron will magnetize it. The use of the magnet will be fully explained in the description of the Morse system.

Sömmering's system of telegraphing, invented in 1808, was not based upon the action of the magnet, but upon the decomposition of water by galvanic electricity. It consisted of as many wires as there are figures and letters in the alphabet. In other words, it had thirty-six wires. Each wire was put in a tube containing water, and each of the thirty-six tubes had either a figure or a letter placed upon it. The current from the battery was passed through the wires representing the letters in a word or the figures composing a number. The word was spelled out or the number was ascertained by noticing the bubbles in the tube where the message was received.

This, of course, was a very expensive and cumbersome apparatus; and as messages could not be sent rapidly, it was of no practical value.

Samuel F. B. Morse was the first to invent a practical system of telegraphy, and to make it one of the greatest agencies in the advancement of civilization and prosperity.

In 1832, while on his way from Europe to America, he invented his system; and in 1835 he constructed a short line,

but his first patent was not granted until June 20th, 1840.

As early as 1837, he applied to Congress for aid, but was refused. Many persons, among whom was Webster, believed him to be crazy. At last Congress, in 1843, to make the experiment, appropriated the sum of $30,000; and a line was constructed between Baltimore and Washington.

On May 27th, 1844, the nomination of James K. Polk, by the democratic convention, then in session in the city of Baltimore, was transmitted over the wire to Washington. That message immortalized the name of Morse; and succeeding generations will continue to regard him as one of the greatest benefactors of his race.

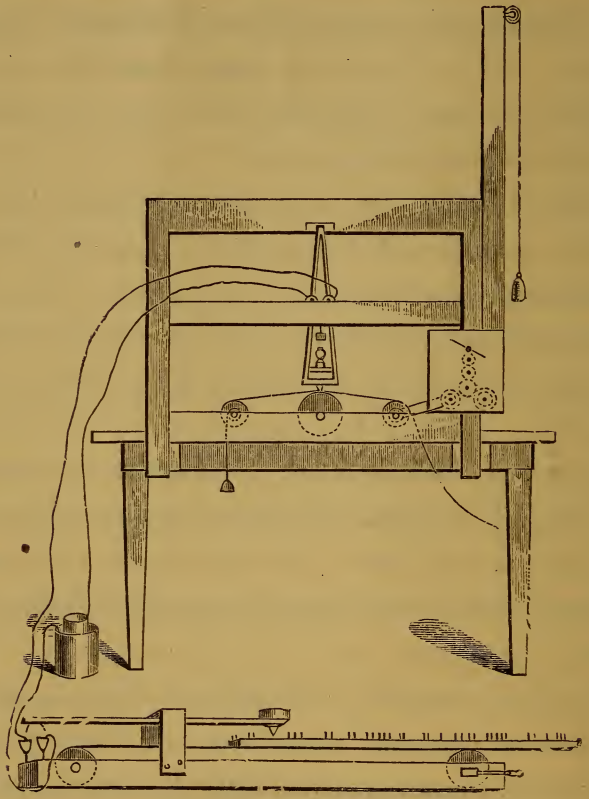
Several discoveries necessarily preceded Morse's invention.

In 1825, Mr. Sturgeon, of London, discovered that a coil of wire wrapped around a bar of soft iron will give it the properties of a magnet, so long as the current of electricity is passing through the wire.

The current produced by the galvanic battery was found to be too weak to overcome the resistance of a long transmitting wire. This was a serious practical difficulty, and was conquered by Prof. Joseph Henry of the Smithsonian Institute, at Washington.

In 1831, he invented the kind of magnet used in the Morse system.

He, also, discovered a means of combining circuits, constituting the important invention of receiving magnet, and the relay



ORIGINAL MORSE MACHINE.

or local battery, as they are now familiarly called. By this combination, a weak or exhausted current can call to its aid, or substitute for itself, a fresh and powerful one.

Morse's invention may be described as follows:

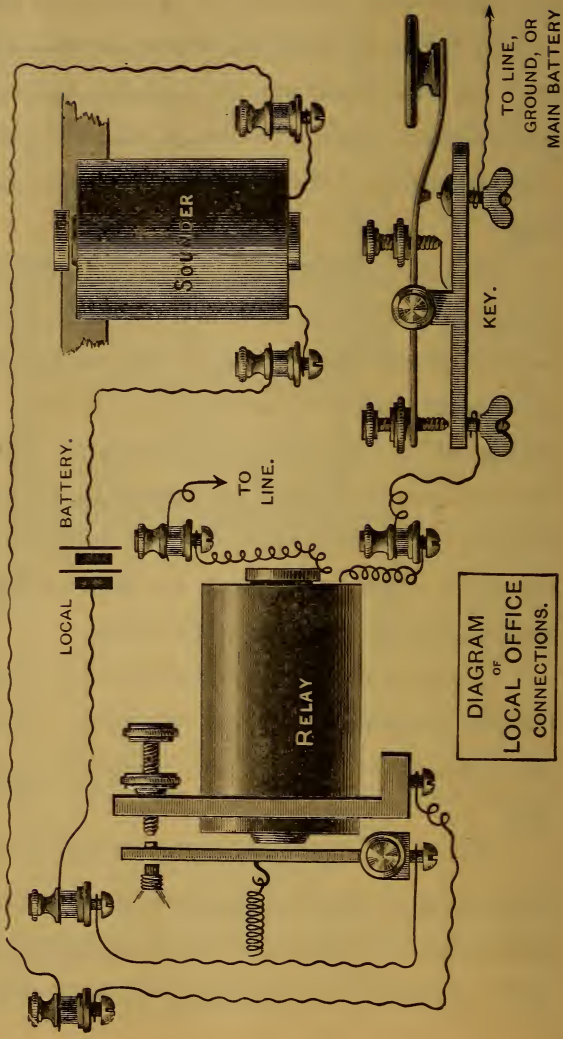
By means of a galvanic battery a current of electricity is sent over the wire which was by a system made and broken so as to move a pencil upon a moving paper; the plan of his instrument was necessarily crude, a view of it being given on the opposite page.

He procured from a blacksmith a horse-shoe shaped piece of iron, around which he wound by hand some copper wire, which he had covered also by hand with cotton thread, thus making his magnet, which he fastened upon a large wooden frame and connected his line wires to it; his pencil holder, which also carried the armature which was moved by the electric action of the magnet, was probably two feet long, made of two wooden strips; the paper ribbon upon which the little characters were scratched was propelled by wooden clock works.

Evolution in this line has at this day produced a much more complete instrument for the telegraph. The view given on the next page shows the "Relay," "Sounder," and "Key" upon one base.

The first being connected to the line and the delicate instrument which receives the impulses from the line, and being a quiet instrument it is made to transfer the signals by the movements of its lever ("armature") to a louder instrument—the sounder, which be-

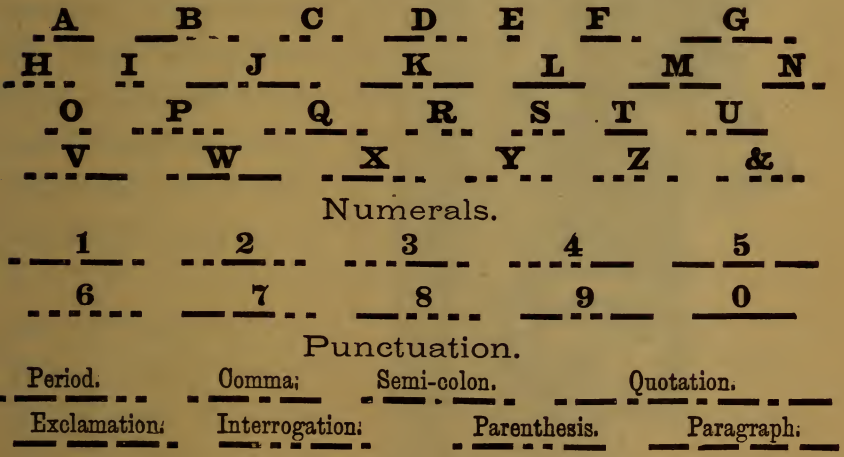
ing fed by a battery in each office where it is, speaks out loud, and trained operators read the message by the hammering of its lever upon the screws; the trained ear quickly measures the length of time it requires to make what on the paper in the older telegraph instrument would be a "dot" and its difference as compared with the "dash," and the alphabet is made up of the combination of dots and dashes.



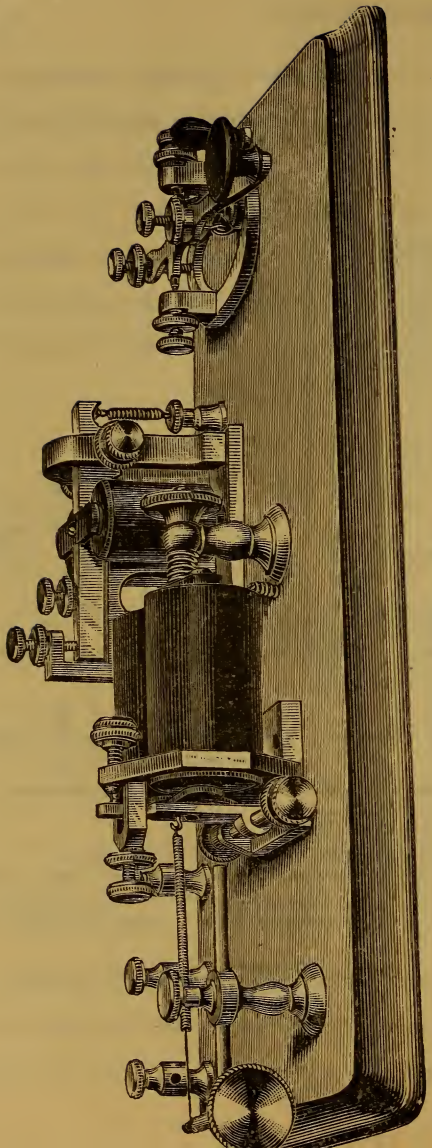
The "key" is the signal or letter sender, it, being connected in the line, breaks the current in all the instruments on the line as its lever is raised, and makes it again as it is pressed down, the letters, therefore, being made up of makes and breaks.

The alphabet made up by Prof. Morse, strange to say, remains in force to this day, and is almost universally used by operators who use the recorders and paper, and the "sound readers" as well, and is as follows:

THE MORSE TELEGRAPH ALPHABET.


A B C D E F G
H I J K L M N
O P Q R S T U
V W X Y Z &
Numerals.
1 2 3 4 5
6 7 8 9 0
Punctuation.
Period. Comma; Semi-colon. Quotation.
Exclamation! Interrogation? Parenthesis. Paragraph;

To those who are interested in the manner of electrically connecting up telegraph machinery, the following picture may be of interest and service to them.



ELECTRICAL TELEGRAPH MACHINERY.

Bain's system was invented in 1845. Like Sömmering's, it did not require any magnet. His was an electro-chemical telegraph, and transmitted messages by recording dots and dashes on chemically prepared paper, placed on a revolving metallic plate. Over this plate was a stylus or sharp pointed instrument, which made the dots and dashes on the paper directly under it.

House, about 1845, also invented an instrument by which the letters of the Roman alphabet are printed on a strip of paper. It has a key-board similar to that of a type-writer, and

by touching a key the corresponding letter is printed on a slip of paper at the other end. The message is thus printed in full and ready to send out by simply tearing off the strip.

This system was at one time extensively used throughout the United States; but Morse's system with slight modifications is now employed throughout the civilized world.

In addition to a number of well used systems of Duplex—sending a message in one direction on a wire while another message is being sent in the opposite direction on the same wire,—and likewise a multiplication of this, as shown in the quadruplex and sextiplex, which are becoming common, a system of multiplex has just been perfected and is now in operation between Boston and Providence, by which, it is claimed, seventy-two messages may be sent over the same wire at the same time, and in the same direction at the rate of three words per minute for each circuit; or thirty-six messages, if sent in opposite directions.

The value of the telegraph to commerce, journalism, and science cannot be over-estimated, and can only be measured by imagining the evils which would follow the loss of it.

Electric Wires.

For telegraphic uses wires of a medium weight or thickness are used, while for telephoning finer wires answer, the difference being that the telephone uses feeble currents, the telegraph heavy battery power; but for electric lighting the heaviest wire is required on account of the intensely heavy current necessary to be carried.

With the vast increase of wires for all purposes, like great cobwebs, in our large cities, the apprehension is growing that soon the light from heaven may be considerably darkened, to say nothing of the homeliness of the arrangement(?).

The owners of wires are crying to the law makers and the executive departments of cities for further liberties and the people are arraying themselves against a continuance of the present privileges.

The electrically interested people are dreading the expense of putting the wires under ground and are fearful lest, in telephony especially, they may be defeated in transmission by the earth's interference, for the earth is greedy to absorb all the electricity she can steal from the wires.

The undergrounding subject occupies the first position in the general public attention in the large cities to-day, and grave are the doubts about successful working for long periods, and certain is the excessive cost of a wholesale removal from above surface to below it.

Be the conduits designed as they may, the writer is doubly sure the most important requirement is good "insulation," which means the covering on the wires which keeps the electric current from escaping.

Telegraph Ocean Cables.

The first submarine telegraph cable was laid by Dr. O'Shaughnessy, in 1839, near Calcutta. The telegraph line was twenty-one miles long, seven thousand feet of the wire being submerged. The submerged wire was covered with cotton thread saturated with pitch and tar.

In 1842, Prof. Morse is said to have laid a wire between New York and Governor's Island. These were different, however, in their construction from the cables which now span the oceans and seas, though the principle of sending messages is the same viz: that of telegraphing at a great distance.

Our present system of laying cables in the open sea began by laying a submarine cable between Dover, England, and Cape Grinez, France. This cable was laid in 1850 and was twenty-seven miles long.

It would be quite impossible in a book like this to even name all the cables that have since been laid. As near as the writers can ascertain there have been two hundred and four oceanic cables laid throughout the world (including the one recently laid), fifty-seven of which were not in operation in 1882.

The writers, will, therefore, confine themselves to giving a short history of the Atlantic cables by which our own continent has been linked to Europe and through which we are daily made acquainted with the important events happening throughout the civilized world.

In 1857, the steamships "Niagara" and "Agamemnon" endeavored to lay a telegraph cable between the coast of Newfoundland and Ireland, but without success. The next year they made a second attempt, which proved successful. The sixteenth

day of August, 1858, is memorable on account of a message and reply transmitted between Queen Victoria and President Buchanan.

This was the first time in the world's history that the rulers of two great nations had conversed across the ocean. During the first twenty-three days four hundred messages were sent. It then lost its conducting power and was abandoned.

Inseparably connected with this transatlantic cable enterprise is the name of Cyrus W. Field, who by his perseverance and untiring energy, both in this country and in England, secured the necessary means for its accomplishment.

In 1865 an attempt was made to lay a second cable, and the immense steamer "Great Eastern" was entrusted with the enterprise.

The work of laying the cable commenced on the 23d of July. After working for several days, during which a considerable portion of the cable was laid, it parted and the broken parts could not be found. This cable was even stronger than that of 1858.

In 1866, this enterprise was undertaken a second time by the "Great Eastern," and was entirely successful. She also grappled the end of the one laid the previous year, and spliced it: so that there were two lines of trans-atlantic telegraph.

The length of the cable in each case is about sixteen hundred nautical miles.

It was nowhere placed more than two and seven-tenth miles below the surface of the water. It was paid out at the rate of six miles per hour, and the length of the inclined plane between the bottom and the ship was seventeen miles.

On the 16th of June, 1873, the "Great Eastern" assisted by three other steamships, each fitted out with all the necessary appliances for laying and picking up cable, began the work of laying the fifth Atlantic cable between the coast of Newfoundland and Ireland. During the first eleven days, the "Great Eastern" laid seventeen hundred miles of it.

Siemens Brothers, near London, manufactured this cable.

It consists of a thick central wire which runs through a peculiar composition. Eleven smaller wires are placed around it, the composition cementing the whole together. Then it is coated with gutta-percha, and served with manilla fibre until it is three-fourths of an inch in diameter. It is next covered with ten iron wires, each having been previously wrapped with hemp, and passed through two tanks of tar in order that it may be thoroughly coated. Then it is coiled away in large tanks, where it remains until used.

By the above description, the reader has observed that the

cable consists of a wire for conducting the current of electricity and an insulating compound, to prevent the escape of the electricity from the wires; also sheathing and iron armor to protect against rubbing or other injury, and to increase its strength.

It is necessary that the cable should be strong so that it will not easily break, that it should not be affected by the action of the salt water, and that the conducting wire should be insulated to prevent any of its electricity from being carried off by the water, which is a good conductor, and would carry the current to the ground and so cut it off, and destroy the cable's usefulness.

What has been said concerning the usefulness of the telegraph, may be more strongly affirmed of the cable. It has indeed linked the continents of the earth together and enabled us "to speak the world around."

The present cost of sending a message from Philadelphia to Liverpool is fifty-three cents per word.

The Telephone.

"The telephone, which makes a whispering gallery of the round earth," is fast making a very interesting and important history, and at this time while much attention is being drawn to it, diligent search is being made for the beginning and earliest hand in it; among the scraps comes to us quite a clear prophecy of it, dating to 1847, when in London a fairy tale was published in which the story ran:

The little Bee informed the Queen that the "metallic threads" running through the air above would convey "any message you please." The Queen told the Bee what to say, and the "words went tearing through the atmosphere on the wings of the lightning messenger."

The passage is accompanied by a snatch of poetry in which the whole telephonic idea is given:

> "Let their voices be heard
> At a distance no voice could reach!
> And swiftly as thought
> Let the words be brought,
> And the lightning endowed with speech!"

Léon Scott and Mr. Barlow were the first to invent electric

telephones, which recorded the vibrations on a travelling ribbon by means of a delicate marker. But the telephone did not become of practical or commercial value, until it was made to convey these vibrations directly to the ear.

This is done by means of a "receiver," which contains a magnet for reproducing the vibrations.

In order to understand the telephone, it is necessary to know how sound is produced.

Voice is produced by the action of the breath upon the cords in the throat. The cords being made to vibrate by expelling the air from the lungs, produce sound in the same manner as the string of a violin when the bow is drawn across it.

This sound or voice is converted into words by means of the organs of speech viz: the teeth, tongue, lips, and palate.

These modified vibrations leaving the mouth set the air in vibration. The vibrations, or waves of air, striking upon the ear, produce modified sounds or words. In other words, sound is nothing more than vibrations or waves of air falling upon the ear, which converts them in a mysterious way into sound.

The different sounds depend upon the number of vibrations per second, the lowest number which will produce it being sixteen.

To Reiss, of Germany, the credit is given of having first

transmitted musical sounds through a telegraph wire by electrical means.

He used a square wooden box, through a hole in the front of which he inserted a speaking tube mouth piece, and over a hole in the top of the box he tightly stretched a membrane.

Any sound produced in the box would set the air within in vibration, and cause the membrane to vibrate. To the centre of the membrane was fastened a piece of platinum and connected by wire to the other end of the line; against this platinum a suspended piece of platinum rested. This was connected through a battery and the circuit made complete through the ground or by a return to the opposite end.

As the membrane was moved it disturbed the electric circuit and this was sent to the other end and was correctly repeated. The receiver was made of an iron bar mounted on a sounding board. Around the rod was a coil of wire.

A current on this line and through this wire magnetized the bar and caused vibrations and faithful rendering of the pitch of tones thrown into the transmitting box.

Elisha Gray, of Chicago, in 1874, improved this by having a faithful reproduction in giving the variable intensity as well as the pitch of a sound. Afterwards he added quality to it, and as a result articulate speech was accomplished; but to Prof. A. Graham

Bell, of Boston, the credit is generally accorded of accomplishing this in the most effective manner.

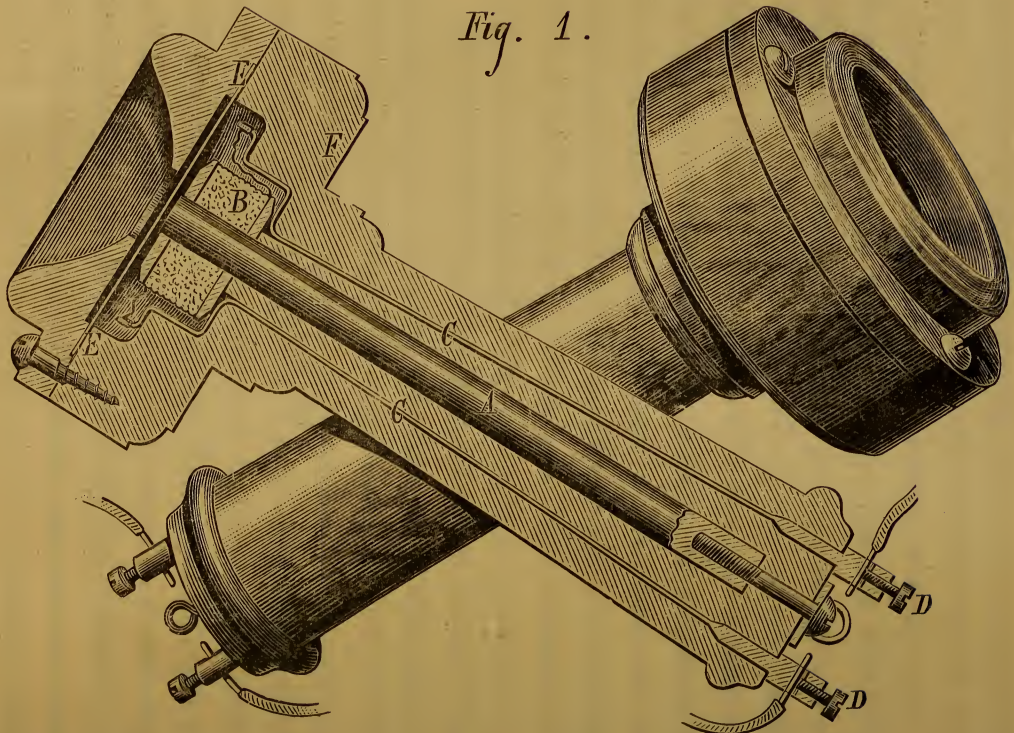
Many, however, are the aspirants to-day to divide the great honors with him and much good coin has been and is at the present time passing to the treasury of the legal fraternity in the contest.

Daniel Drawbaugh, of Pennsylvania, is the chief contestant, and claims priority. Unlike some of the other contestants, neither he nor his companies have done anything in creating and operating a system, and nothing comparatively is known as to the form of instruments they would use, but it is to be presumed that if successful in the present legal contest, they would build up a system from simple forms somewhat similar to the present Bell instruments.

Many have been the contests between the company operating under the Bell patents and others who have, at least, made important improvements upon the system, and a great many of these contests have resulted in a union of interests: among the many workers whose improvements have been added to the Bell system are Dolbear, Gray, Edison, Berliner, Blake, Irvin, Gower and Hunnings; to give fully the work of each in this volume would be quite impossible.

The Bell Telephone is shown on the following page in two views; one shows the external appearance, the other the parts which compose it.

Fig. 1.



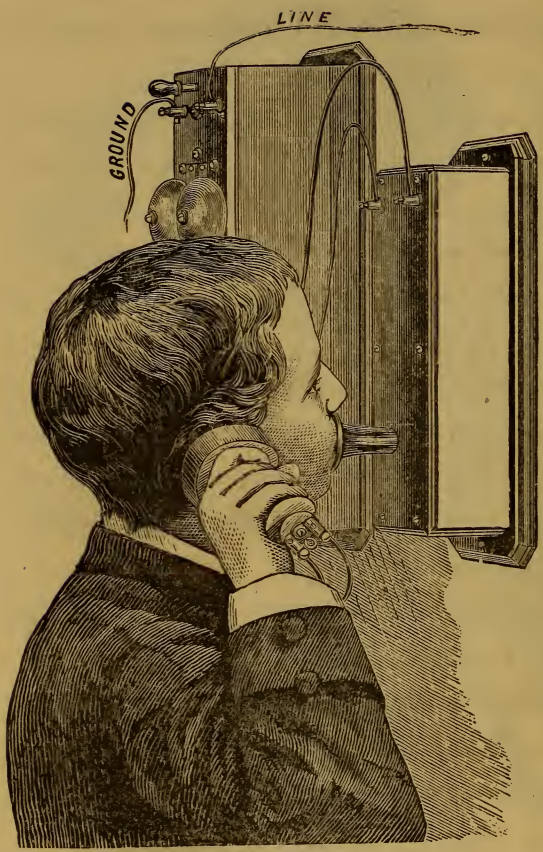
DOUBLE VIEW OF BELL TELEPHONE.

The cut shows so plainly the form, that description seems almost needless, though a brief explanation of the parts might be desired by some.

An electro-magnet or spool of copper wire is fastened to the end of a steel bar which has been charged with magnetism; the ends of the wire are carried down to the outer part of the rubber case, and connected by screws to the line wire. In front of the spool, and a little way from the end of the bar magnet, a piece of "ferrotype" sheet iron is placed.

When a current of electricity is sent into the telephone and through the spool of wire, the sheet iron plate is caused to vibrate in unison with the breaking of the current, by reason of the alternate attractions and cessations of attraction of the plate by the electro-magnet, and a sound is produced.

An additional view is given of the operation of using the first Bell Telephones, in which a magnetic telephone was used for speaking, but as improvements in strength of "sending" or transmitting telephones were demanded, Dr. Blake, of Massachusetts, designed and invented the instrument now so generally used, called the Blake Transmitter, which is a square box with opening through the door; on the inside of the door an iron plate is loosely held, against the inside of which is hung and supported by a spring, a platinum bead; beyond this is a carbon button suspended in the



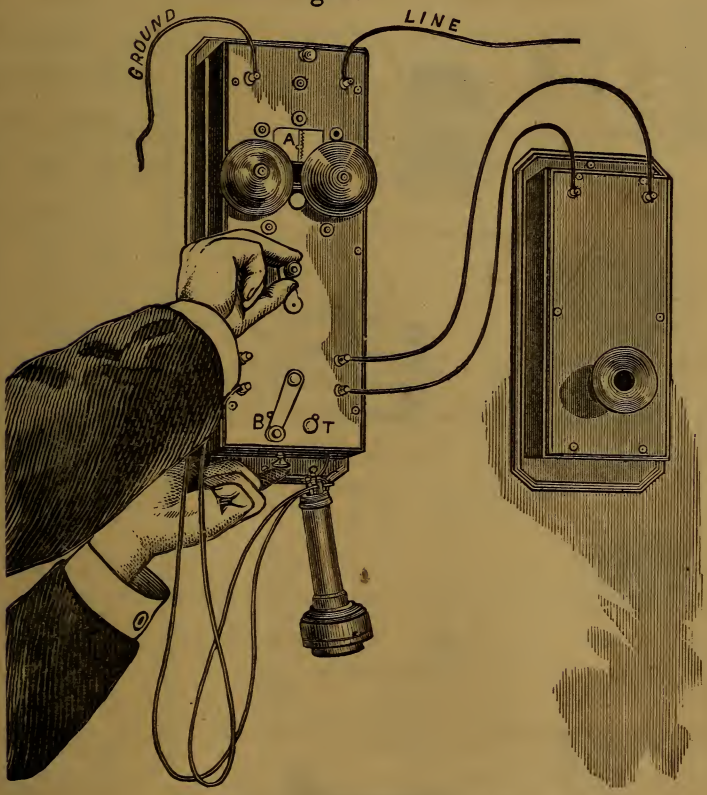
THE FIRST BELL TELEPHONE.

same way; these two springs are in the circuit of a battery, and as one speaks against the plate or "diaphragm," the point of contact against the carbon button is displaced and changed, and variations of intensity produced in the current.

The adjustment of the springs is so nicely regulated, that the varying pressure between the contact points is carried to the Bell Telephone, which is the receiver at the other end of the line, and there faithfully interpreted.

For the purposes of signaling, a magnetic generator is used to ring bells. This generator is made of steel horse-shoe mag-

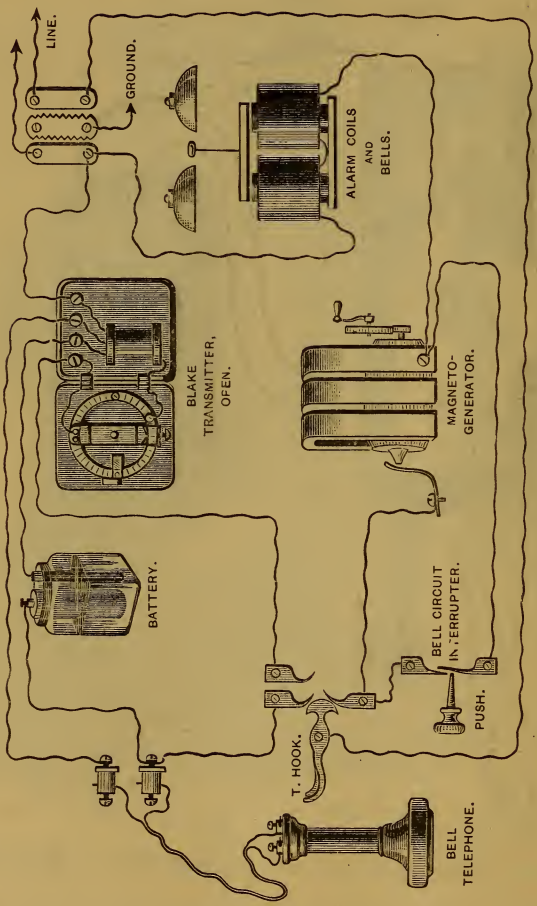
Fig. 1.



GENERATOR, TELEPHONE, ETC.

nets, with a revolving pair of spools of copper wire, with iron centres near the ends of the horse-shoe; by turning a crank, the

spools are revolved, and so a current is sent which rings the bells.



ELECTRICAL CONNECTIONS—TELEPHONE INSTRUMENTS.

The cut on the preceding page shows the full Bell Telephone set, of the original "Bell" pattern, and, although old, shows distinctly the separate instruments making up the set for signaling, speaking, and hearing.

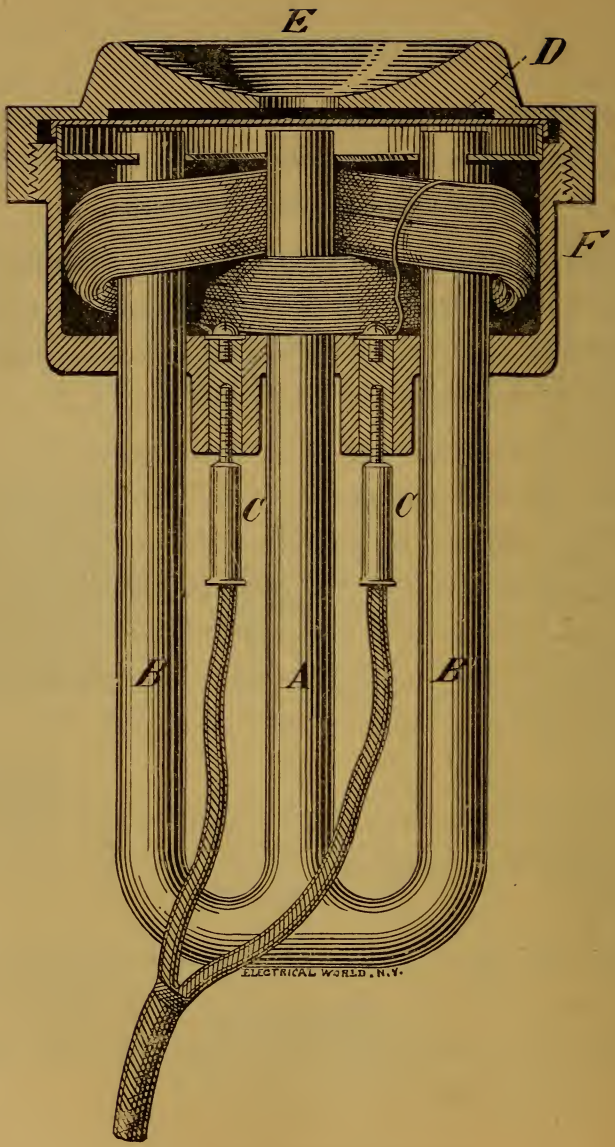
To the student or operator, the diagram given in the preceding page will be of value; it shows the wire connection between the parts of the Bell Telephone standard equipment.

Daniel Drawbaugh, of Eberly's Mills, Pa., claims that his first electrical transmission of articulate speech dates back as far as 1860, and that such a way of talking by wire was a dozen years old when Mr. Bell announced his triumph.

From an examination of the models exposed to public view for a few days after the opening of the Electrical Exhibition at Philadelphia (and then covered over, or removed, because the case was being adjudicated in the United States Circuit Court of New York), one would be led to suppose that Bell, Edison, Blake, and Righi had all been peeping through Mr. Drawbaugh's key-hole and stealing designs for their instruments and improvements.

It does sometimes occur, however, that striking resemblances are brought out simultaneously by inventors far removed from each other.

This brief dissertation on telephones would be incomplete were we to omit the Clay telephone, the one which has probably shown the most earnest purposes of competition with the companies operating under the Bell patents.



CLAY TELEPHONE RECEIVER.

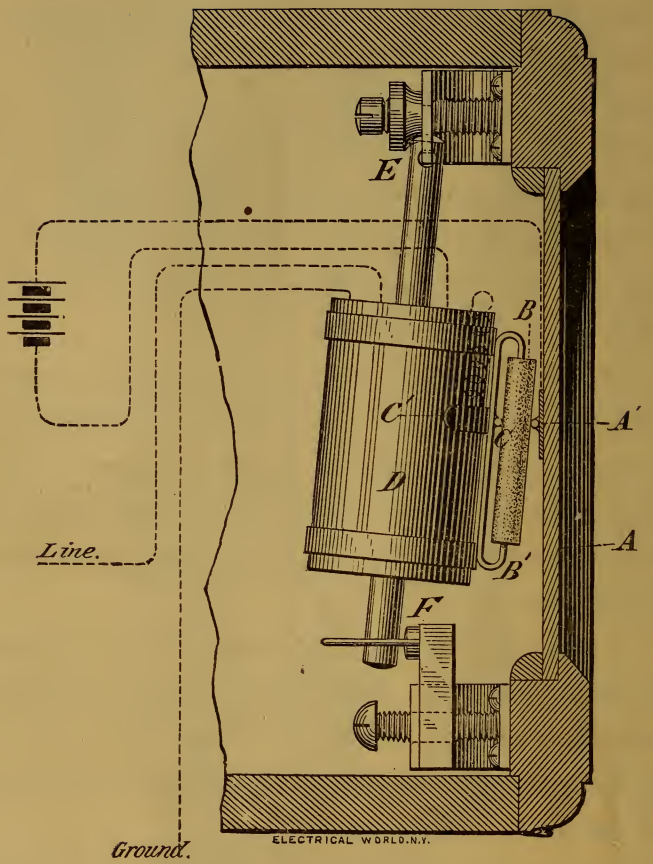
The cut on page 74 shows the Clay receiver, which is quite fully described by the picture. Its principal parts are a three pronged steel magnet wound with wire as shown, and with the usual plate of iron in front. The middle limb is one of polarity, say positive, and the two outside ones are of the opposite or negative.

A virtue is claimed for the peculiar form of winding on the magnet, and that disturbing effects from other lines and cross-talk from other wires is obviated.

In the Clay transmitter, the usual induction coil is used, as in the Blake transmitter, but the manner of doing so is very different. This coil's weight is used, by the peculiar hanging of it, to press a carbon pencil against the "speaking plate," which will be readily understood from the cut of transmitter, which gives a sectional view of the box.

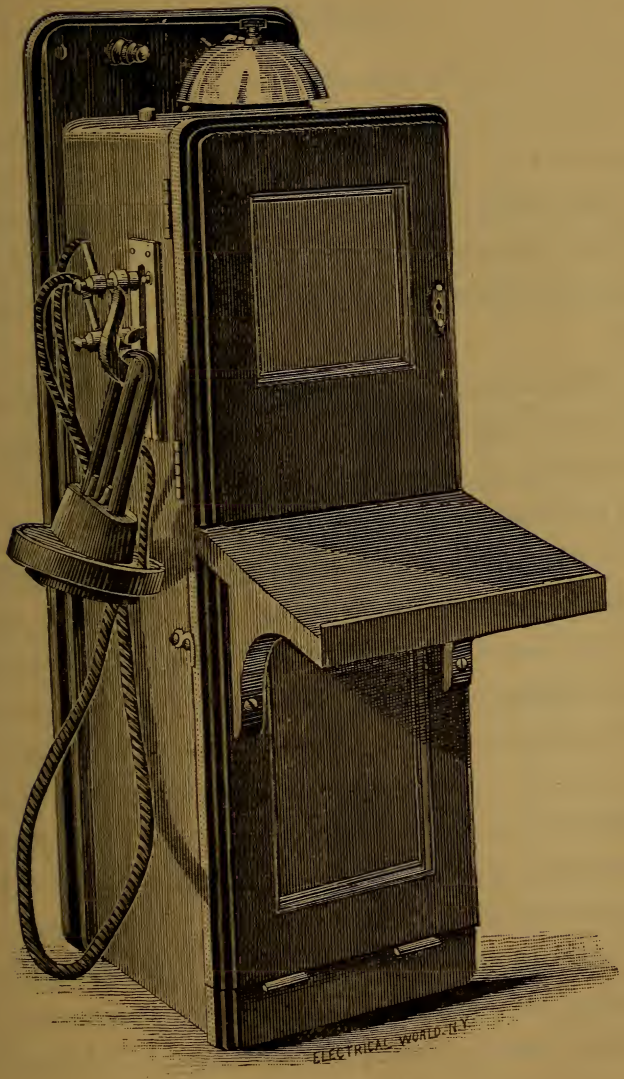
To cause transmissions the words are directed against the square panel above the shelf, which causes its vibration and consequently a series of changes in pressure on the carbon pencil inside, this is sent upon the wire and to the receiver at the opposite end of the line.

The most recent aspirant, who claims priority of invention antedating all others by several years, is one Antonio Meucci. He is making some stir in the telephonic world, through what is claimed to be a strong combination of capital and experience.



CLAY TRANSMITTER.

This transmitter is inclosed in the signal box to be seen in the next cut, which shows the Clay complete set.



CLAY COMPLETE SET.

Electric Light.

The electric light is produced by passing a current of electricity through a filament, or thread, of carbon, or between two sticks of carbon fixed at the positive and negative ends of the circuit.

Voltaic electricity may be used, or electricity generated in magnets by magneto-electric or dynamo-electric machines.

The latter source only is of any practical value for lighting streets or buildings, and will be fully described hereafter.

The light emitted by fire-flies and glow-worms is attributed by some to electricity in the body, and the nervous action by which they flash is thought to be in the nature of voltaic impulses from the battery—the brain. However, this is only speculation.

The attention of the public was first called to the electric light in the year 1846, by the patent of Greener and Staite.

Their lamp consisted of an arrangement by which small pieces of pure carbon, inclosed in air-tight globes, were made brilliant by passing currents of galvanic electricity through them.

To describe the lamp more fully, two small bits or sticks of pure carbon were fixed so that their points would nearly touch each other. In this position they were kept by means of clock-

work, which automatically adjusted them as they wore away, by slowly moving them towards each other. A current from the battery was transmitted through these sticks, but the circuit could not be completed without spanning the small space between the two points. The carbon being slightly separated and also a poor conductor, an intense heat at the points was produced, together with an intensely brilliant light.

According to the dynamic theory, previously mentioned, the more resistance a body offers to a current of electricity the more rapidly its molecules are made to vibrate, and the hotter it becomes, as a matter of course. When the carbon is heated to a white heat, it makes a very brilliant light.

Platinum cannot be used for lighting purposes, because it becomes so hot as to melt.

The principle of the electric light, therefore, consists in passing a strong current of electricity through a resisting body, which will neither melt nor be quickly consumed.

The dynamo machine or generator of electricity, used for the production of the electric light and motive power, consists of an armature, or ring of soft iron (sometimes surrounded by a wire), which, by steam or other power, is made to revolve between the poles of a single magnet, or between two magnets; which, in short, is a transformation of *work* into *electricity;* and while this means

seems to be, and is complicated, it is the most economical where powerful currents are used.

The horse-shoe magnet will serve to illustrate it. The ends of the shoe are called the poles—positive and negative. Between and around these poles is the "field" of the magnet. If an armature be made to revolve rapidly in this field or between these poles, the magnet becomes strongly electrified at these points.

Positive electricity having a strong affinity for negative, it is only necessary to produce a current to connect the two poles, or ends, of the magnet.

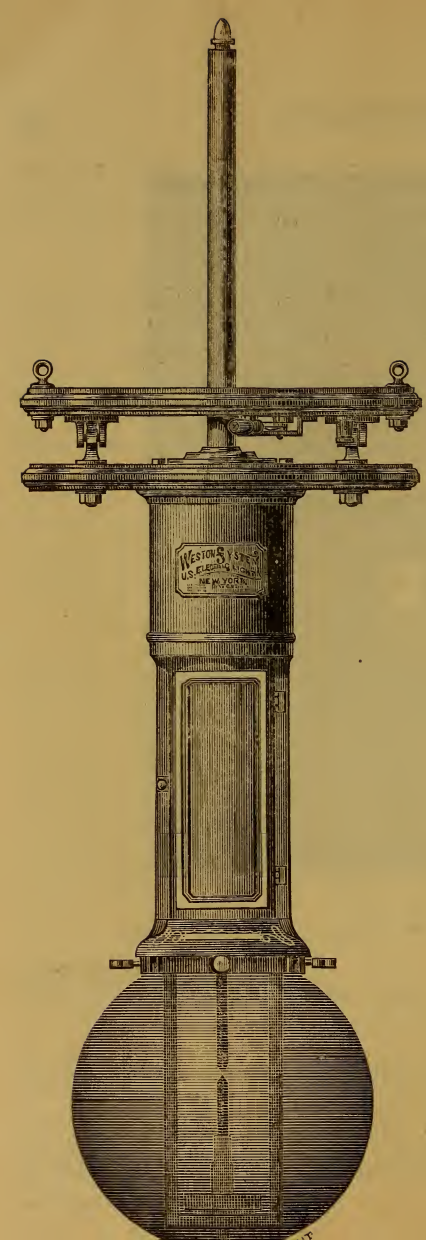
To produce the electric light, attach a conducting wire to the negative pole of the magnet, and a stick of carbon to the other end of the wire. In like manner connect the positive pole of the magnet and bring the two sticks against each other, and let the electric current pass between them. As the connection so made is poor, heat is produced, and, the sticks of carbon being separated, the force of the current throws off from the surface and ends of the sticks, the carbon in small particles, heated up to a state of incandescence.

Illumination is thus accomplished by this process of vaporizing, transferring, and throwing off in great numbers, these particles which form an *arc* of light between the ends of the two sticks of carbon; hence the name of lamps in which carbon is consumed—"arc lights."

ELECTRIC ARC.

A view is here given of the appearance of the burning carbons in the arc lamp.

This is an enlarged view of the arc lamp, in the box of which, above the globe, the mechanism and magnets are contained, for feeding and regulating the carbon sticks, which are seen within

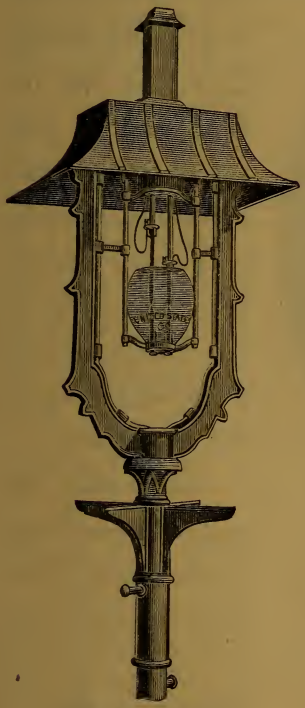


the globe. The upper stick is in the positive side of the current, and the lower one in the negative. In the first the consumption is about one inch per hour, and half as much in the lower, so that it is necessary to visit the lamps every day and renew the carbons.

Many of the lamps are made with double carbons for double length of service without attention, and are used in winter, for all night work, etc.; but during the actual burning of the lamps the devices, which differ in the different systems, so nicely control the feeding that the consumption is regular.

Carbons are generally made from the coke-like accumulation which fastens itself to the

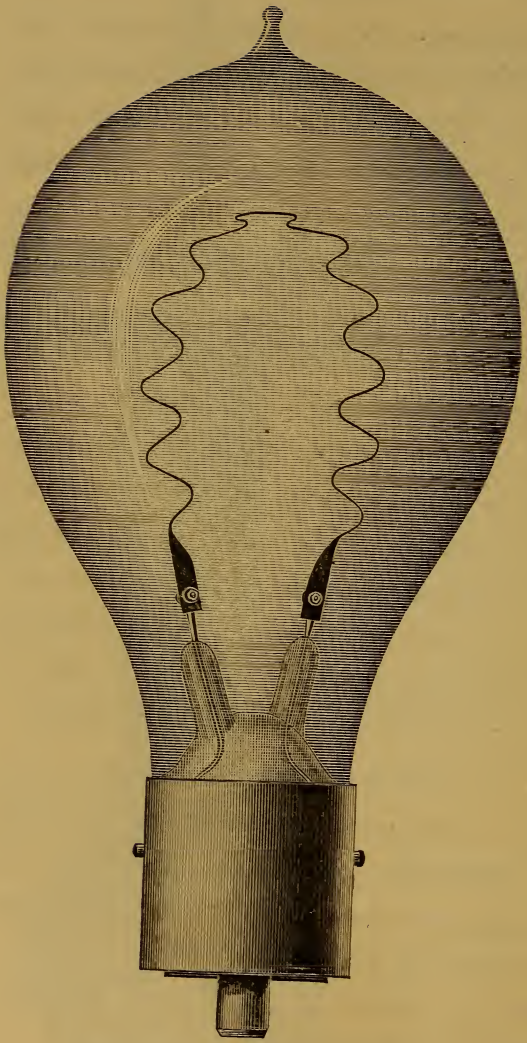
inside or ceiling of gas holders. It is ground fine, mixed with some substance like molasses to hold it together, and baked hard. The sticks cost about three and a half cents each, twelve inches long, when bought in very large quantities.



LAMP AND HOOD.

A contracted view is given of an arc lamp as it is prepared for street work, with hood for protection from the weather. We believe the system of street lighting was first introduced in this country in 1878 on Manhattan Beach. The growth since then of city illumination by lamps upon posts and upon high masts and towers, erected at street junctions, has become more or less extensive throughout the world.

It will be remembered there are these two general classes of electric lamps, one being that just named—the arc—in which *carbon is consumed*, and the other, the "incandescent," or that in which there is no consumption of carbon but a *heating only*, which is accomplished by having the fine carbon filament kept in a vacuum or sealed globe, from which air is excluded.



WESTON INCANDESCENT LAMP.

The incandescent lamp is usually made to give a less intense light than the arc lamp, and is best adapted to home and lighting small rooms, although latterly very large lamps of this class are being introduced for lighting large spaces.

The names *arc* and *incandescent* are misnomers to a certain extent, for in the arc light the illumination is due to incandescence of the particles of carbon thrown off; and again, there is a form of lamp like that of

Varley's, Werderman's, Reynier's, &c., which is classed incandescent and yet one piece of carbon—a pencil—is consumed where it presses against a block of carbon. This form is very little used, and probably not at all in the United States at this time.

A view is here given on the opposite page of a Weston incandescent lamp of improved form of carbon. This is given as a type of the general form of incandescent lamps.

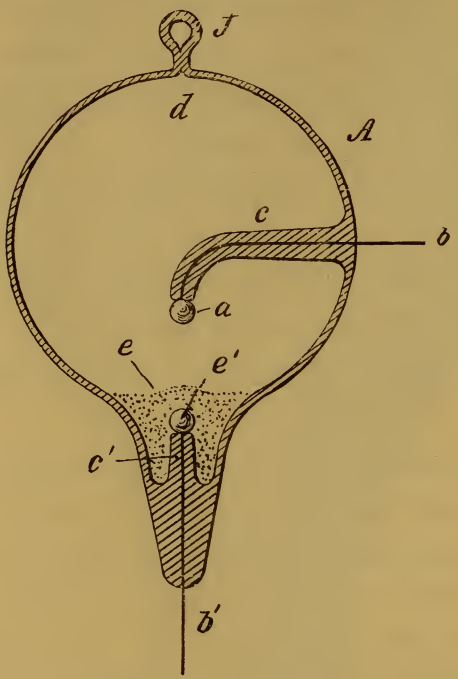
The filament, or wick, of these lamps has generally been made of carbonized paper, silk or other thread, and fibre of bamboo wood as in the Edison lamp, while the one shown is made from a new substance named *Tamadine*, and in chemical composition, much the same as paper or vegetable fibre, but without fibrous structure.

In making this class of lamps nearly all the air is exhausted from the globe, before it is sealed up, by the use of mercury pumps.

This is probably the future light for our homes, as from it no gases are given off to vitiate the air; also very little heat. Another valuable consideration is its perfect safety from fire. The wish that its production and maintenance may soon be cheapened is becoming general.

Within the past few days we have been admitted into the secrets of a new invention in incandescent lamps. If the expectations of the inventor, Mr. Beck, of Paris, are realized, a step in

advance will be taken and a valuable accession made to the comfort and conveniences of rural homes, as well as to those located within reach of the central lighting systems of the large cities, where the electric power is distributed through mains to all subscribers on the way.



BECK'S LAMP GLOBE.

The important feature of this invention is the making of an incandescent lamp which is run by a battery, and which can be carried about like a kerosene lamp.

The globe is the peculiar part of the lamp and a description of it will doubtless be of interest to many. It is made in about the same way as any globe for incandescent lighting; that is, it has all the air exhausted from the glass globe, and two wires which are extended to the inside of the globe through closely sealed places. Unlike other lamps, these ends are separated

a short distance, as may be seen by the view presented.

In this form of the lamp, one wire enters on the side and ends with a ball of platinum ; the other enters at the bottom.

Into the globe, before it is sealed, is put a small quantity of finely powdered and very dry charcoal; also some nitrogen gas, and a very small amount of metallic mercury in form of vapor.

The gas holds the solid particles of carbon in suspension in the path of the electric current, which jumps across between the points of the wires. The current heats up these pieces of carbon to a white heat, but cannot burn them because they are in a vacuum.

The mercury is intended to assist the current of electricity in passing between the ends of the wires.

These globes are erected on the top of a stand which contains a coil of wire and what is called a "condenser," which is made of lead and paper sheets. The effect of the condenser and coil is to give the current, which comes from the battery located just below it, an intense power for heating the carbon.

There is also a proposition to introduce the plan into the more general system of lighting, such as covering the houses, &c., in a district, from a central battery place.

Probably the hopes of the majority of the people into whose

homes the electric light will not find an entrance for a long time, will be realized by the perfection of the "*Storage Battery*."

What is it? The reply will be simple: boxes of convenient size are made, for instance, 6 inches wide, a foot high and a foot long; they are lined with lead so as to be water tight. Into these are put lead plates, on edge, separated by pieces of wood or similar material.

These plates are pitted or full of holes, which are filled with a paste formed of red lead and other substances, and the whole is immersed in acidulated water. Every other one of the plates is strapped together with a lead band on one corner, and the intermediate ones on the other corner. A dynamo-electric machine is then connected by wire to these straps, and set in motion, and so sends a powerful current into the boxes. The effect of which is to form a coating of brown oxide of lead, on the plates connected on that side of the battery, making them powerfully electro-negative towards the metallic lead of the other plates.

Without entering into the chemical action to a fine degree, suffice it to say that the electricity is sent by wires into these plates and accumulates in the oxide on them. It can, at pleasure, be drawn off in small or large quantities, and used for light or any purpose.

At the present time the cost is considerable, but it is being

cheapened, and may soon be within the reach of the common people. It is necessary, however, to live along the route of a wire by which the storage batteries may be fed daily, or as they are exhausted.

Their weight, at the present time, makes the carrying of the lead batteries to and from the dynamo for charging impracticable.

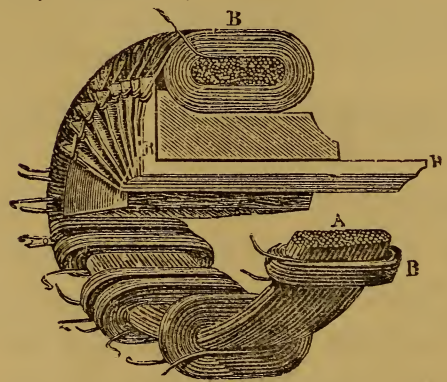
Dynamo-Electric Machines.

We now return to the subject of the best source of electric power for powerful currents.

The "dynamo" is made up of two fundamental parts; the *armature* and the *field magnets*. While in the early forms the field magnets were made in part of steel pieces in the form of a horse-shoe, our description may well omit that form and only require the reader to look at the nature and make-up of the form most in use now for lighting and power purposes.

Since the dynamo-electric machine is rapidly taking a place in mechanics, where it will have more or less to do with our every day life, the reader will do well to give it more attention and study than these pages afford.

Gramme's modification, in 1870, of what is called the *ring armature*, constructed by Page in 1852, was the beginning of the most important progress in the mechanical production of electricity. Since then applications of this mode of producing force have been a succession of rapid strides. In nearly all of the present leading forms of machines, it can be seen that the inventors have been close students under Gramme. With the use of this armature continuous currents are produced, while with previous machines only momentary ones were possible.



GRAMME ARMATURE.

The cut here presented shows the Gramme armature in such a way as to allow its construction to be seen.

The core or centre of it is made of a bunch of soft iron wires, and is wound about with wires covered with cotton to keep them separated—insulated.

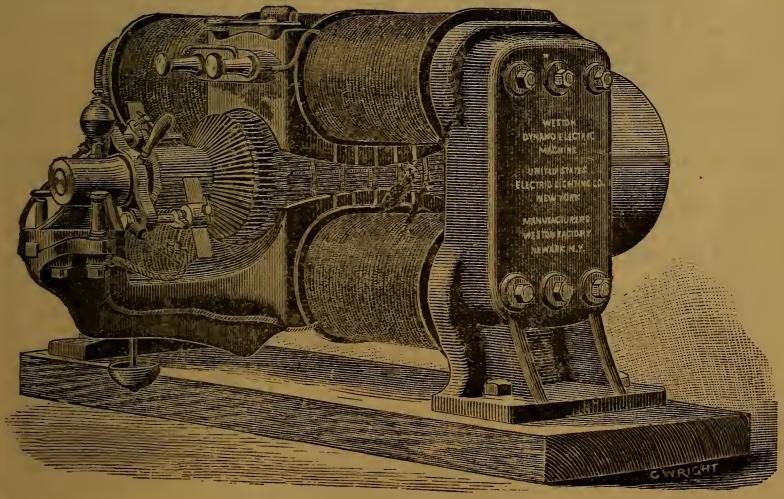
The ends of the little spools of wire are brought out and fastened to a flat copper strip laid upon the axle, which passes through the centre of the ring. This large spool is then mounted by its axle on proper bearings. The stationary magnets, called

field magnets, are placed closely up to this ring, but not touching it. Upon the axle a belt wheel is put so as to have steam engine power turn it very fast.

As the ring is revolved a current is generated, and flows out with every change in its position.

The current so made is carried out by brushes which press upon the terminal plates of the wires in the ring. These brushes are connected to the wires running out to the lamps.

A view is here given of one of the improved Dynamos of the present time, and its general plan may be understood.



WESTON DYNAMO.

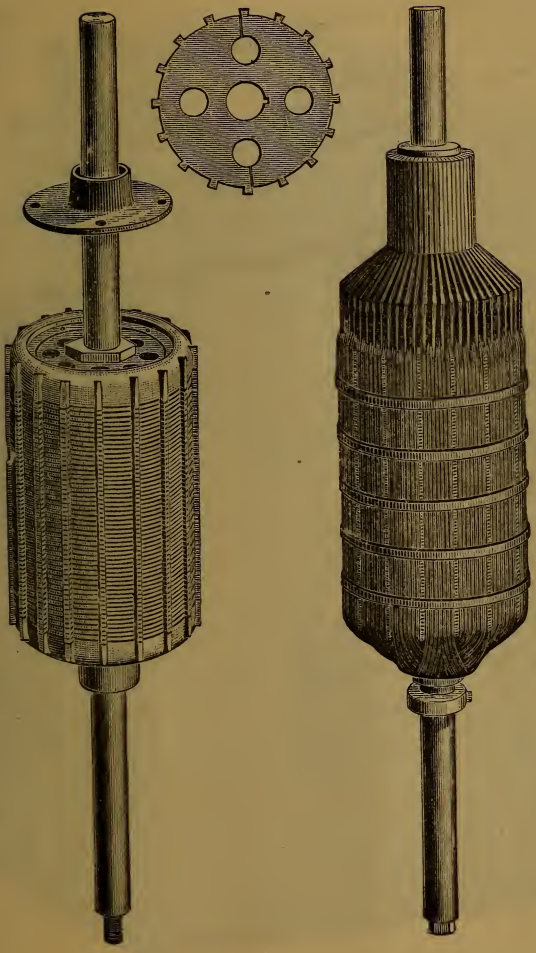
The general shape of the field magnets is that of a horse-shoe. Copper wire is wound around an iron centre and four of these spools are connected by the frame in pairs. Each pair is placed upon opposite sides of the ring armature, and the faces turned so as to bring the ring's surface very close all around.

How the armature of this machine is made may be learned from the cut here presented, which shows the details on an enlarged scale.

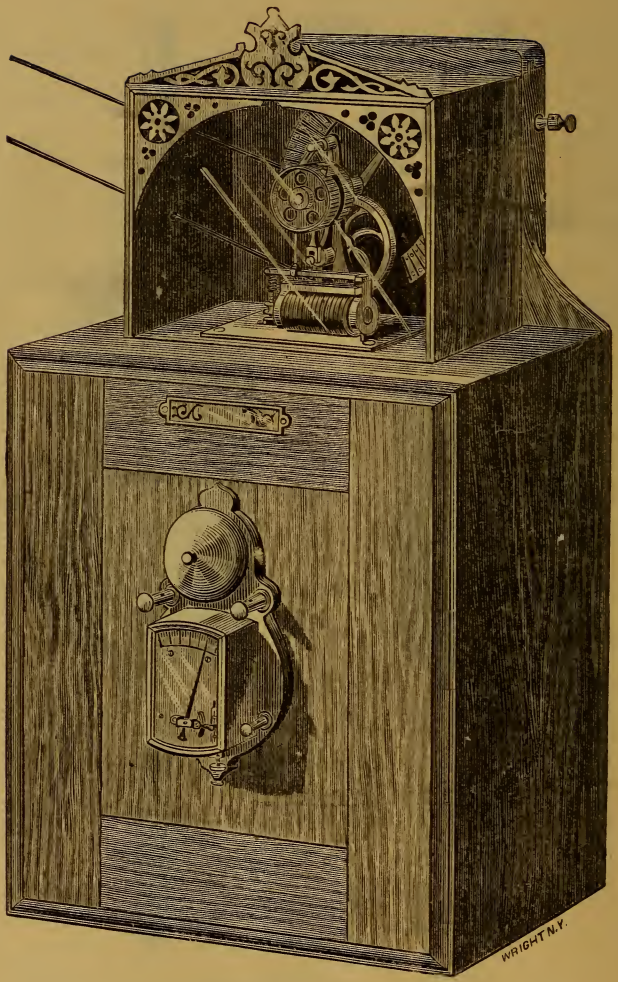
This core is made up, as may be seen, of discs of iron laid side by side, and then wound with a small amount of copper wire.

Improvements have recently been made in many of the dynamos by the employment of a separate governor, by which the intensity of the field is automatically regulated, so that in the event of any number of the lamps being cut out by accident, the others will not be affected by the strong current which otherwise would burn or do other damage somewhere in the circuit.

The cut on page 94 shows one of these regulators. It also by a pointer shows just what work is being done.

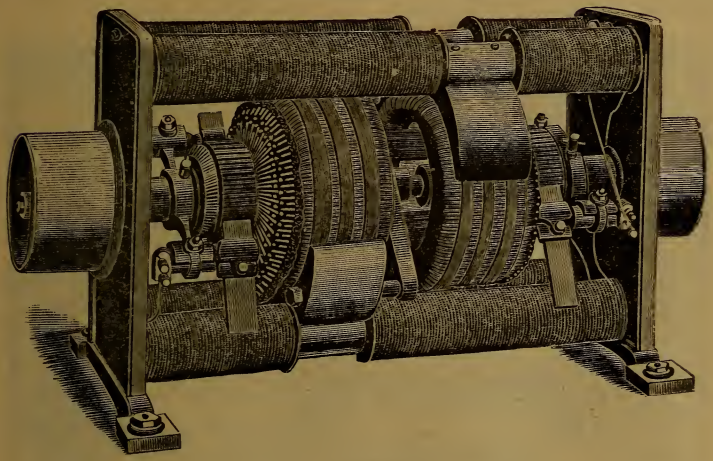


ARMATURE OR CORE.



AUTOMATIC REGULATOR FOR WESTON ARC SYSTEM.

Another form of dynamo machine, for which a new principle is claimed, is the invention of Chas. E. Ball.



BALL DYNAMO.

While in the usual dynamo the armature is rotated between both poles of a field magnet, this one has two bobbins or armatures, each rotating near a separate field pole.

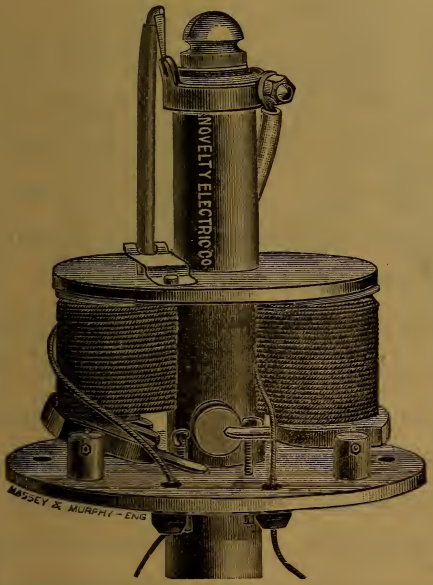
From this machine both arc and incandescent lamps may be used at the same time, on separate circuits of wire.

Gas Lighting.

GAS LIGHTED BY ELECTRICITY.

Among the valuable uses of electricity, few are more pleasing than the lighting of gas.

In theatres, churches, and such places, plate machines of a modified form are successful in lighting by a single flash several hundred jets of gas.



AUTOMATIC BURNER.

Over the gas opening of each burner two wires are carried, the ends of which point towards each other, and are but slightly separated. The current is sent by wires from the machine. (A battery with a spark coil does the same work.)

Through the house the wires are placed under the plaster and are hidden away out of sight.

In residences the system is to run a wire from the cellar, or where the battery and spark coil are, to each gas fixture.

The burners are of an especial kind, the most complete being what are called "automatic" (one is shown with part of its shell removed to show its parts).

Wires are run from this burner to a double press button on the wall, or suspended over the bedstead. By touching the white knob of the button, electricity is made to move a magnet which turns on the gas in the burner and makes at the same time a spark which lights it. Touching the dark knob of the button shuts off the gas in the burner in the same way.

GAS LIGHTED BY PULLING CHAIN.

In another form where the burner can be easily reached, the gas is lighted by pulling a little chain which hangs down out of the globe. Two battery points are brought together and a spark created, and so the gas is lighted.

In a complete system, the wires all run through an annunciator, where, in case of accident to the burners or other parts, a little flag is dropped down, upon which can be read the name of the burner that is in trouble and at the same time a bell is rung calling the servants—all done by electricity.

These burners are often connected with doors and windows and so fixed that when a burglar opens the house the gas is lit in his face and in the servant's room.

Among other contributions to the comfort and conveniences of our homes the *portable torch* is fast occupying a place. In its

handle there is a sealed up battery and spark coil; in its stem, a sparking point, which when held within the flow of the gas causes its ignition.

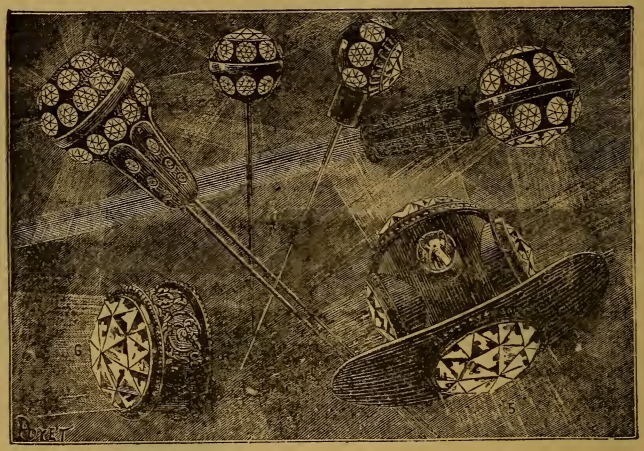
Improvement has been made in this instrument by which the chemical battery and coil are replaced by an arrangement somewhat similar to a dynamo machine.

Among the various uses of electricity, one now occupying the attention of the theatrical managers is interesting.

Incandescent lights are used for stars on fairies' heads, etc.

The accompanying illustration shows various articles of

jewelry, each containing a small incandescent lamp, a full-sized sketch of which is appended. No. 1 is a hair-pin; 2 and 3 breast-pins; 4, the head of a cane; 5, a diadem for a tiara; and 6, a large gem, intended to be set in a necklace, for theatrical effects. The wires



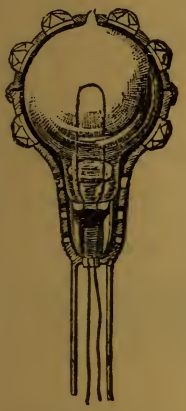
INCANDESCENT LAMPS IN THE FORM OF JEWELRY.

are enclosed in a small supple cord concealed in the dress, and a switch within easy reach permits of turning the current on or off at pleasure. The practical use that we see in these jewels is that, in returning home late at night, they afford a ready means of brilliant illumination, which would aid in the finding of a lost object on one's way, and also the way to the key-hole, etc. It is said that the walking-stick, provided with a large diamond, affords sufficient light to read a newspaper by. If set with say a white

gem on one side and a red one on the other, it may be used for signaling to a distance, while the switch would enable a communication to be carried on by means of the Morse alphabet.

Considerable ingenuity is being exercised in creating more than brilliant jewelry, by surrounding miniature lamps with cut glass in many forms. By the light streaming out from the little electrically illumined carbon in the centre, many stage and scenic requirements are met, particularly in diadems, girdles and gems to be worn by foot-light sylphs.

The cuts given, were described by *The Electrical World* recently.

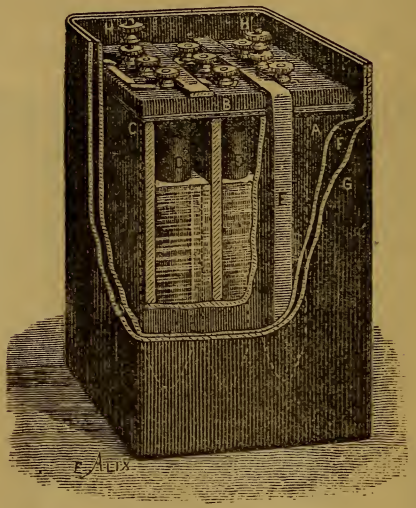


SECTION OF ELECTRIC JEWELRY.

The little lamp in this cut has one side removed to show its inner construction. The ordinary incandescent lamp fully described in previous pages is used. In Paris instead of relying upon the accessibility of a dynamo current, they have a form of battery shown on page 102, worked by a bichromate of potash solution.

The duration of incandescence varies nearly in the ratio of the capacity of the battery. The smallest, shown full size in the cut, is capable of maintaining illumination for twenty or twenty-five minutes;

while one twice the size, which may be carried by a belt attached to the outside cover, will maintain it for an hour.

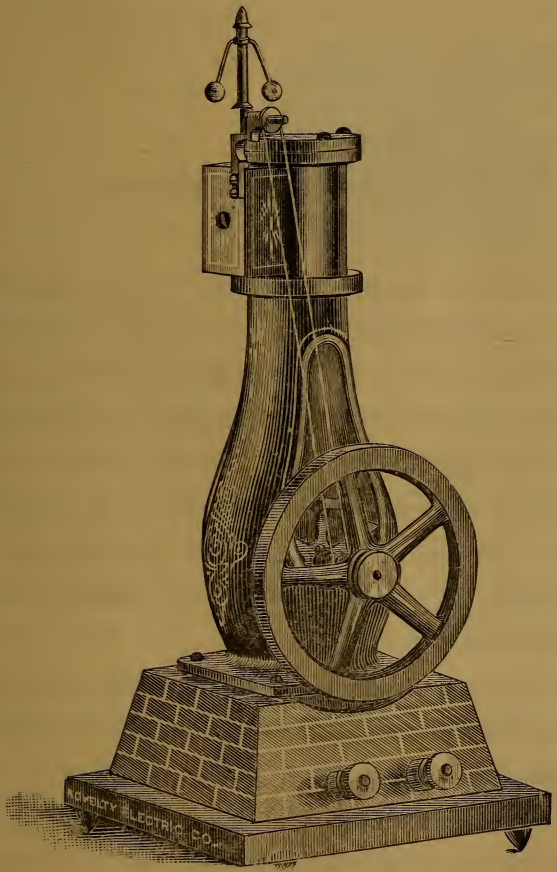


JEWELRY BATTERY.

For theatrical effects of short duration, as many as twenty-five lamps have been kept going at the same time. The battery can also be recharged in a few minutes by renewing the solution.

In *electric toys*, one of the electric manufacturing companies of this country has made a great success in well designed and cheap forms of machines operated by electric power.

Among the handsomest being those representing engines, boats, etc., propelled by power from a carbon battery. These instruments not only amuse but teach the young the



ENGINE RUN BY MOTOR.

principles underlying electric motive power and mechanics.

In the view given an electric motor is attached to and surrounds the axle on which the balance wheel is run.

The Electro-Motor.

Electro-motive power is produced by the great attractive power of the electro-magnet; that is a magnet formed by passing a current of galvanic electricity through a bar of soft iron.

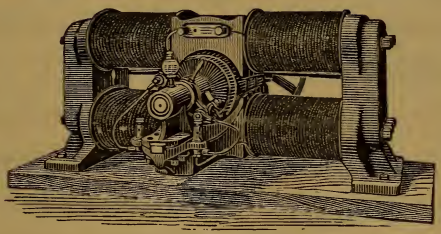
The first electro-motor, large enough for any practical use, was constructed by the celebrated Russian, Philos Jacobi.

In 1839, by the use of one of these motors, he propelled a boat, carrying ten persons, at the rate of four miles an hour. Instead of the dynamo, he obtained his electrical force by means of a powerful galvanic battery.

In Denmark, a patent was obtained in 1849 by Mr. Hijorth, for an electro-motor engine of ten horse power. This was the most powerful then in existence.

The large motors now used are run by dynamo machines. In the dynamo, as was explained, the rapid revolution of the armature produces the electrical force; but in the motor, the electrified magnet causes the revolution of the armature. The *motor* is, therefore, the *reverse* of the *dynamo*.

The electric motor is made by putting a ring of soft iron, or armature as it is called, between the poles or ends of a horse-shoe magnet. The armature is then said to be in the field of the magnet, and is made to revolve by passing a current of electricity through the magnet.



ELECTRIC MOTOR.

In one of the forms lately presented, there is a hinge in the back or curve of the magnet, and the armature is made to revolve rapidly or slowly by bringing the poles or ends of the magnet near it, or removing them from it by means of a thumb-screw. (Generally the speed is controlled by regulating the amount of current fed to the motor.) A wheel is placed on the end of the armature, and in this way a sewing or other machine is belted on to it and set in motion.

The motor has the advantages of being noiseless in its action, can be easily moved from one place to another, is safe, easily controlled, and free from dirt.

It is very finely adapted to the manufacture of mathematical, optical, and other delicate instruments.

The impression that the great attractive power of the electro-magnet could be profitably applied to machinery was so great at

one time that an appropriation of $20,000 was made by Congress, and one of $120,000 was made by Russia to experiment in this direction.

A great many machines were invented for using it as a motive power, but in no case was it found to be so economical and efficient as steam.

What the future will bring forth no one can safely predict. Dynamo machines are run by steam, gas, or water power; and of course do not produce as much power as the engine exerts in running them, because there is necessarily some loss from friction.

Every time power is transferred from one machine to another, some of it is lost.

In motor work, first coal is burned to run the steam engine, which by belts or by direct connection of the shaft, revolves the bobbin of the dynamo electric machine, and thus creates a current. The motor is then connected by wires to this current which causes its armature to revolve and do the work by directly turning the drill or by further belting, putting in motion other forms of machinery. It is therefore readily seen how, in so much re-transmitting of the power from the coal pile to the drill or sewing machine, much loss must necessarily be sustained.

Street railways are adopting this form of power and in Cleveland seem to be successful.

In one system proposed, the rails are used to carry the electricity from the home station. All along the road the cars get the power by carrying the current through their wheels to motors on the cars. The motor causes the car axle to revolve and so runs the car.

The fact that electrical force can be conducted great distances suggests the possibility of utilizing waterfalls to run the dynamo to generate the electricity, which can be conducted to motors in factories miles distant.

Conclusion.

As an applied science, electricity has not yet reached its teens. Slumbering for ages, it has suddenly awakened to a new existence, and has developed during the last ten years in a manner truly startling. In fact it has become a growing necessity of the age.

In the form of automatic signals, it warns the engineer of impending danger. As an electric organ, it is made to play sweet and delightful music. As a flash light, it illuminates the dark face of the deep for miles; and in various other ways, many of which have been explained, it supplies the wants of our advanced civilization.

The International Electrical Exhibition, given in the city of Philadelphia under the auspices of Franklin Institute, displayed in the grandest manner, the power, production, present and possible uses of electricity that the world has ever seen.

Yet who will say that the next decade will not produce a grander one having all the present developments as a nucleus?

The human intellect is continually unfolding and developing its powers, so that the impossibility of to-day becomes the possibility of to-morrow, the probability of day-after-to-morrow, and an accomplished fact the succeeding day.

The Almighty has stored the air, the sea, and the land with forces which were permitted to slumber, until He allowed them to be called into activity, as they were required to meet the wants of successive generations.

Electricity is but one form or manifestation of this force; and judging from the past decade, we are justified in the belief that during the next, the application of it to the various wants of society will far exceed our most sanguine expectations.

If the reader has acquired even a partial knowledge of the subject, the writers have been amply repaid for their toil; and especially so, if this casual view incites the reader to more careful study of this attractive and fruitful branch of science.

THE END.

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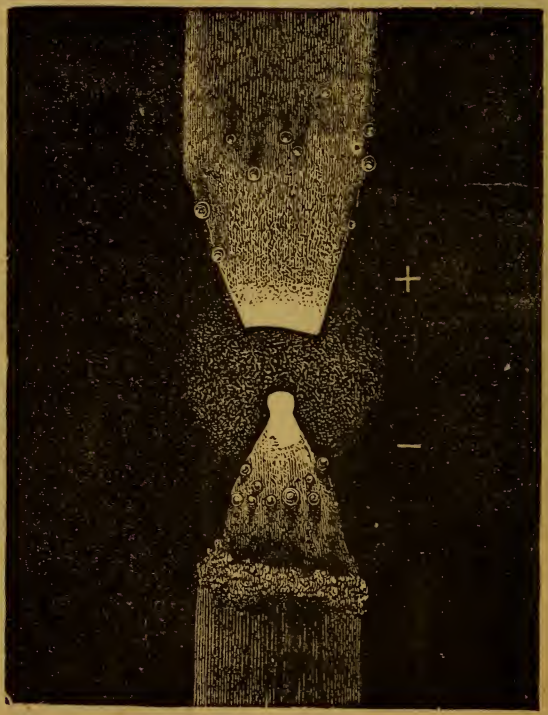

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